ABET
Self-Study Report

for the

Bachelors of Science in Civil Engineering

at the

University of Colorado Boulder

Boulder, Colorado

July 1, 2017

CONFIDENTIAL

Table of Contents

BACKGROUND INFORMATION 5

A. Contact Information 5

B. Program History 5

C. Options 6

D. Program Delivery Modes 6

E. Program Locations 6

F. Public Disclosure 7

G. Deficiencies, Weaknesses or Concerns from Previous Evaluation(s) and the Actions Taken to Address Them 7

CRITERION 1. STUDENTS 9

A. Student Admissions 9

B. Evaluating Student Performance 10

C. Transfer Students and Transfer Courses 11

D. Advising and Career Guidance 13

E. Work in Lieu of Courses 15

F. Graduation Requirements 16

G. Transcripts of Recent Graduates 17

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES 18

A. Mission Statement 18

B. Program Educational Objectives 18

C. Consistency of the Program Educational Objectives with the Mission of the Institution 19

D. Program Constituencies 19

E. Process for Review of the Program Educational Objectives 19

CRITERION 3. STUDENT OUTCOMES 21

CRITERION 4. CONTINUOUS IMPROVEMENT 23

A. Student Outcomes 23

Outcomes Assessment Methods Summary 23

Outcome 1. [a] Apply knowledge of math, science, and engineering fundamentals 26

Outcome 2. [b] Design and Conduct Experiments 29

Outcome 3 [b]. Analyze and Interpret Data 32

Outcome 4 [c]. Design a System or Component 34

Outcome 5 [d]. Multidisciplinary Teamwork 37

Outcome 6 [e]. Identify, formulate, and solve engineering problems......................39
Outcome 7 [f]. Professional and Ethical Responsibility..41
Outcome 8 [g]. Effective Communication through Writing and/or Drawings..........44
Outcome 9 [g]. Effective Communication through Oral Presentations 47
Outcome 10 [h]. Understand the impact of engineering on society.........................50
Outcome 11 [i]. Necessity to Engage in Life-Long Learning (LLL).......................52
Outcome 12 [j]. Contemporary Issues 56
Outcome 13 [k]. Modern engineering techniques, skills, and tools.........................59
Outcome 14. Explain Concepts in Management, Business, Public Policy, and Leadership 61
B. Continuous Improvement...63
C. Additional Information...66
CRITERION 5. CURRICULUM 67
A. Program Curriculum 67
Table 5-1 Curriculum 69
Curriculum Alignment with Program Educational Objectives 73
Mapping Curriculum to Student Educational Outcomes 74
Curricular Areas and General and Program Criteria...77
Major Design Experience 78
Cooperative Education 81
Course Syllabi 81
CRITERION 6. FACULTY... 82
A. Faculty Qualifications...82
B. Faculty Workload..83
C. Faculty Size 83
D. Professional Development 88
E. Authority and Responsibility of Faculty 89
Table 6-1. Faculty Qualifications 93
Table 6-2. Faculty Workload Summary 96
CRITERION 7. FACILITIES.. 101
A. Offices, Classrooms and Laboratories 101
B. Computing Resources 103
Campus-wide/Institutional Computing Resources 103

C. Guidance ... 109
D. Maintenance and Upgrading of Facilities ... 109
E. Library Services ... 110
F. Overall Comments on Facilities ... 112
CRITERION 8. INSTITUTIONAL SUPPORT ... 113
A. Leadership ... 113
B. Program Budget and Financial Support ... 113
C. Staffing ... 115
D. Faculty Hiring and Retention ... 116
E. Support of Faculty Professional Development ... 117
PROGRAM CRITERIA ... 118
Appendix A – Course Syllabi ... 127
Appendix B – Faculty Vitae ... 193
Appendix C – Equipment ... 289
Appendix D – Institutional Summary ... 291
1. The Institution ... 291
2. Type of Control ... 291
3. Educational Unit ... 292
4. Academic Support Units ... 292
5. Non-academic Support Units ... 293
6. Credit Unit ... 293
7. Tables ... 293
Table D-1. Program Enrollment and Degree Data ... 294
Table D-2. Personnel ... 295
APPENDIX E – Rubrics Used for Direct Assessment ... 296
Signature Attesting to Compliance ... 327

Program Self-Study Report
for
EAC of ABET
Reaccreditation

BACKGROUND INFORMATION

A. Contact Information

Balaji Rajagopalan
Professor and Chair
Civil, Environmental, & Architectural Engineering (CEAE)
428 UCB
University of Colorado at Boulder
Boulder, CO, 80309-0428
Phone 303-492-5968, fax 303-492-7317
E-mail: balajir@colorado.edu
primary pre-visit contact person for the program

Angela R. Bielefeldt
CEAE Assessment Coordinator and Professor
Phone 303-492-8433, fax 303-492-7317
E-mail: angela.bielefeldt@colorado.edu
primary author of this self-study

B. Program History

The Bachelor of Science in Civil Engineering (CVEN) degree at the University of Colorado Boulder (CU) is offered through the Department of Civil, Environmental, and Architectural Engineering (CEAE), which resides within the College of Engineering and Applied Science (CEAS). Civil Engineering was one of two engineering majors offered in 1893 when the School of Applied Science was first established as part of CU. The Bachelor of Science degree in Civil Engineering was first accredited in 1936. In the 2011-2012 general review by the Engineering Accreditation Commission of ABET, our program received a Next General Review with accreditation through Sept. 30, 2018.

Significant curriculum changes since the 2011-2012 academic year, which formed the basis of the previous ABET review, are highlighted below. Since the previous review, the civil engineering curriculum has changed to a structure requiring all students to take a fundamental course in each of five sub-discipline areas of civil engineering (construction, environmental, geotechnical, structures, and water resources; previously six, with transportation removed), and requiring students to select three areas of proficiency (from five choices of construction, environmental, geotechnical, structures, and water resources; previously students selected four areas of proficiency). In addition, two separate three-credit courses in geomatics and engineering drawing were changed to two-credits of geomatics and 1-credit of drawing. Changes in the required courses made room in the curriculum for a new two-credit Professional Issues course in the senior year, which was directed at enhancing student education in professional skills. It also opened space to add two free elective courses (six-credits total), more congruent with other engineering programs at CU. In addition, students previously selected one area of concentration within civil engineering (from among construction, environmental, geotechnical, structures, and water resources) requiring two courses in that area; currently students have more freedom in selecting two civil engineering technical electives of interest (these need not be within a single sub-specialty). These changes took effect for the fall 2013 students, and students already in the program were allowed to decide whether to graduate under the old or new program requirements.

The curriculum changes were primarily driven by the concern noted by the previous ABET accreditation visit, feedback from the Joint Evaluation Committee (JEC) process, feedback from students about the difficulty scheduling courses to both meet their interests and allow for on-time graduation, improved compatibility with the open option first year engineering program when students transferred into civil engineering, and educational research on student autonomy and motivation (self-determination theory). The JEC process is described below in section D and in Criterion 2, part E. Additional changes will be taking effect in fall 2017, and will be described where relevant in the continuous assessment and evaluation process.

C. Options

The current civil engineering curriculum does not offer any options, tracks, or concentrations.

D. Program Delivery Modes

The bulk of the required Civil Engineering curriculum is provided to students via courses offered between 8 am – 5 pm on weekdays on the Boulder campus as traditional lecture/laboratory/recitation courses. Humanities and social science electives may be taken as web-based or distance education courses through CU Continuing Education, but that is not common. Some technical electives could also potentially be taken as web-based or distance education courses.

The program offers an optional 5-year Cooperative Education ("Co-Op") program with three alternate curricula plans involving industrial Co-Op assignments, but co-ops do not fulfill any of the curricular requirements and few students participate.

E. Program Locations

The program is regularly offered at the University of Colorado Boulder main campus. Students may participate in Study Abroad programs offered by the University and transfer some of these credits into the major. Students also sometimes take summer courses from other institutions that can be transferred into the major, subject to the approval of the departmental transfer course evaluator.

F. *Public Disclosure*

The program education objectives and student outcomes are published in the catalog of the University of Colorado Boulder. These are also published on the website of the CEAE Department (http://www.colorado.edu/ceae/about/undergraduate-degrees/educational-objectives-outcomes?qt-quicktab_educational_outcomes=1#qt-quicktab_educational_outcomes). The program educational objectives and student outcomes are also published in the Undergraduate Advising Guide for Civil Engineering that is published online at the departmental website and distributed to students. The annual student enrollment and graduation data is posted on the College of Engineering & Applied Science (CEAS) website (scroll down to the Degrees tab: http://www.colorado.edu/engineering/about/rankings-facts-figures?qt-funding_enrollment_degrees_quick=2#qt-funding_enrollment_degrees_quick).

G. Deficiencies, Weaknesses or Concerns from Previous Evaluation(s) and the Actions Taken to Address Them

The previous ABET Final Statement included a single program concern. This concern related to the program criteria, and is directly quoted below:

Program Concern

1. Program Criteria Program criteria for civil engineering programs require the curriculum to explain the importance of professional licensure and require the program to demonstrate that faculty teaching courses that are primarily engineering design in content are qualified to teach the subject matter by virtue of professional licensure or by education and design experience. Of the department's 46 faculty members, only 10 are licensed professionals and only six of those are licensed to practice in Colorado. Professional licensure is an important aspect of the civil engineering profession and the lack of professional licensure among the faculty may diminish student perceptions of the importance of licensure and may reduce flexibility in assigning design courses and in the development of design depth within students' programs of study.

In response to the concern that was identified, the curriculum was revised to add a new two-credit Professional Issues course. The course was designed and is taught by a faculty member who is a licensed professional engineer in Colorado. The course has a strong emphasis on the importance of licensure, devoting time to preparing the students for the Fundamentals of Engineering exam, discussing the importance of licensure, and requiring students to read and become familiar with the American Society of Civil Engineers (ASCE) Body of Knowledge 2nd Edition (BOK2). This reinforces the content on professional licensure that was already included in the first-year Introduction to Civil Engineering course and the capstone design course in the senior year. There has also been a wider effort to increase the number of professionally licensed engineers who are faculty members in the department. Advertisements to hire CEAE faculty members have routinely included language that: “Professional registration or an ability to become registered as a professional engineer is desired.” There are currently 14 professionally licensed engineers among the CEAE departmental faculty, including 7 licensed in Colorado.

GENERAL CRITERIA

CRITERION 1. STUDENTS

A. Student Admissions

At the University of Colorado Boulder, students apply using an online application to a specific major. The campus-wide Office of Admissions in conjunction with the Engineering Director of Access and Recruiting handles the admission process and admission decisions for all engineering majors. While there are not set minimum requirements for admission, the College seeks to admit applicants with a high probability of successfully completing their undergraduate engineering degree program at the University of Colorado Boulder. The Office of Admissions and the College consider the following factors in making admission decisions:

- Evidence of scholastic ability and accomplishment as demonstrated by grade point averages, tests of scholastic aptitude and achievement (ACT or SAT), class rank, grades earned in courses directly applicable to an engineering academic program, and essays.

- Personal motivation and academic success as demonstrated by trends in the student's academic record, rigor and challenge of coursework, success in the academic community, ability to balance academic and personal interests, and letters of recommendation.

The College is committed to increasing the quality of its programs, in part by increasing the holistic diversity of its students (ethnic, gender, geographical, cultural, socio-economic, and first-generation students). This commitment is reflected in the admissions process and the special programs established to support these students.

The following mean average information is provided from prior first-year classes in this College:

Mean Averages, First-Year Classes

New Studs Entering in	High School Rank	HS GPA	ACT Math	ACT Engl.	SAT Math	SAT Crit. Read	# of New Studs
Fall 2016	88%	3.91	31	30	677	615	1032
Fall 2015	89%	3.91	30	30	679	625	900
Fall 2014	88%	3.90	30	30	673	617	909
Fall 2013	89%	3.88	30	29	677	615	838
Fall 2012	87%	3.87	30	29	673	613	778

For more information about first-year admissions, see http://www.colorado.edu/admissions

Due to large increases in the size of the incoming freshman classes, and heightened student interest in specific majors, the College has implemented several enrollment management policies over time. Currently, when students apply to the College of Engineering and Applied Science from high school, they may indicate to enter the College as "open option" (unsure of engineering major), or they may select a preliminary engineering major.

Sometime after completion of the first semester, and by the eighth week of the second semester, all students should finalize their choice of major in the College. Students wishing to make a major change within the College use the Change of Major Form to finalize their choice of major.

Students with a CU cumulative GPA of at least 2.250 after their first semester will receive immediate confirmation of their major choice. See http://www.colorado.edu/engineering-advising/get-your-degree/first-year-freshmen/confirming-your-major for details.

B. Evaluating Student Performance

The electronic Degree Audit was designed to monitor student progress for all Civil Engineering B.S. requirements, including Humanities/Social Sciences, Math, Natural Science, Free Electives, as well as Civil Engineering requirements. The degree audit shows all transfer coursework, AP and IB credit, any coursework completed and coursework in progress. The degree audit points out any remaining requirements: major, math, science and Humanities/Social Sciences and free elective hours. The Civil Engineering staff advisor initially worked with the Registrar's Office Degree Audit team to design the degree audit based on the degree requirements and continues to work with them to revise requirements as needed. Courses that are approved by petition are pointed to the specifically approved requirement substitution or exception. Students in their first two years of the curriculum meet with the staff advisor before each registration period to discuss progress and any remaining requirements. Junior and senior students must meet a faculty advisor. A plan for future semesters is also established and discussed each semester according to changes. Discussion also includes probation/suspension, minors, study abroad, internships, careers, etc. A registration hold is placed on student accounts and is not removed until they have met with an appropriate advisor. Course pre-requisites and co-requisites are automatically checked by the course registration system. Students may request to have a pre-requisite or co-requisite waived by the course instructor (see below). If the student does not have the necessary pre-requisite for a course and the pre-requisite is not waived, the student is not permitted to take the course.

Students are awarded grades on a course-by-course basis. For each course, students earn grades A (4 quality points) through F (0 quality points), augmented with plus (+) and minus (-) which add or subtract 0.3 quality points from the letter grade they accompany (except that no A+ is available). These grades are used to compute a grade point average (GPA) every semester and an overall cumulative GPA for courses taken at CU. Grading policies are detailed at http://www.colorado.edu/engineering-advising/get-your-degree/academic-expectations-policies. The course dossiers available during the ABET visit will contain information describing how individual courses are graded.

Students must pass all of the required courses in the curriculum. Some courses in core areas have pre-requisite courses, co-requisite courses, and/or requirements for a number of credits that have been taken (such as 87-180 credits for CVEN 4897 Professional Issues in Civil Engineering and CVEN 4899 Civil Engineering Senior Project Design). It is program policy that any course that is a pre-requisite or co-requisite must be completed with a grade of at least C-. The undergraduate student advisor reviews grades after the end of the semester and informs students that a schedule change is required for students who do not earn sufficient grades in pre-requisite or co-requisite courses. Registration lists of these core courses are also monitored to make sure that students have the necessary pre-/co-requisites. Class listings provided each semester to all faculty indicate whether the registered student has satisfied the pre-/co-requisites. As noted above, students may petition a faculty member to waive the pre-/co-requisite requirements. The CEAE Department requires students to obtain such permission in writing, either via email or a hard copy petition form. These petitions are reviewed on a case-by-case basis and must be approved by the instructor, the student's CEAE faculty advisor, and the Assistant Dean for Students in the Engineering Dean's office. Instructors will generally agree to waive a pre-requisite if it is determined that the student attained the pre-requisite knowledge in some measurable way.

To remain in good academic standing in the College of Engineering and Applied Science, a student must maintain satisfactory academic performance as measured by grade point average criteria and satisfactory academic progress toward completion of a Bachelor of Science degree in the College. For degree-seeking students matriculating at CU-Boulder Fall 2011 semester or later, CU cumulative, semester, and major GPAs should all be at or greater than 2.250 (2.000 for students prior to Fall 2011). Failure to meet these requirements results in the student being placed on academic alert, academic recovery, and/or academic suspension. The CVEN faculty do not have a role in determining the students who are placed on alert, recovery, or suspension. Academic progress in the college is determined by grades and averages as reported and calculated by the Office of the Registrar. See the Academic Standing website at http://www.colorado.edu/engineering-advising/academic-standing for details.

C. Transfer Students and Transfer Courses

External Transfers

External transfer students are admitted to the CVEN program through the CU Boulder Admissions Office, based on criteria set by the College. Similar to the first-year freshman admission process, the College seeks to admit external and internal transfer applicants with a high probability of successfully completing their undergraduate engineering degree program at the University of Colorado Boulder.

To qualify for admission as a new transfer student, the applicant must have completed a minimum of two semesters of college-level calculus and two semesters of science (college chemistry and/or calculus-based physics). If the applicant has less than 24 semester credit hours, an ACT or SAT test score is also required.

To be most competitive, transfer applicants should have a minimum cumulative college GPA of 3.0. Grades of B or higher are expected in math, science, and engineering courses.

Additionally, The College of Engineering and Applied Science guarantees admission to any of its baccalaureate degree programs to students transferring from Colorado public institutions of higher education who meet the following requirements:

- At least two full-time semesters (or 24 semester credit hours) at a Colorado public institution must be satisfactorily completed immediately prior to the transfer
- A cumulative GPA of 3.3 or higher from a Colorado public institution
- Grades earned in individual mathematics, science, engineering and language arts courses must all be B or higher
- Completion, with final grades, of a minimum of two semesters of college-level calculus, along with two semesters of calculus-based physics and/or college-level chemistry, before an admission decision is rendered.
- Completion of admissions application and submission of all required documents by published deadlines

CU Boulder and the Colorado Community College System have an articulation agreement for both admission, as well as general transfer equivalencies of certain engineering courses. The Guaranteed Admission Criteria is designed with the following parameters:

- At least two full-time semesters (or 24 credit hours) at a Colorado public institution must be satisfactorily completed immediately prior to the transfer
- Colorado public institution GPA of at least 3.30
- Grades in math, science, engineering, communications and writing courses must be B or better
- Must complete two semesters of college-level calculus and two semesters of calculus-based physics and/or college-level chemistry.

There are also a number of direct equivalent engineering courses that are part of the articulation agreement and allow community college students to transfer basic math, science and certain engineering courses to CU Boulder. The participating institutions agree to the agreement's policies governing the transfer of credit among Colorado public institutions for students pursuing baccalaureate majors in the College of Engineering and Applied Science.
See http://highered.colorado.gov/Academics/Transfers/ for details. The University of Colorado Boulder Pre-Engineering Transfer Agreement for Community College Students is posted at http://highered.colorado.gov/Academics/Transfers/Agreements/UCB-Pre-Engineering-Transfer--Agreement.pdf. This agreement, and additional information posted at http://www.colorado.edu/engineering/future-students/transferring-cu/colorado-community-colleges, can be used by prospective transfer students to see which specific Colorado community college courses apply towards degree requirements for each of the CU undergraduate programs.

External transfer courses are reviewed by the CU Boulder department applicable to each subject. This process is coordinated by the CU Boulder Admissions Office transfer credit unit. Course equivalencies are entered into u.achieve, the university's degree audit and transfer credit system. This allows equivalent transfer courses to automatically populate the appropriate requirements in a student's online degree audit. In addition, prospective transfer students can use a free online service, Transferology, to look up transfer credit equivalencies, and run a degree audit showing how their current coursework will apply to the CVEN curriculum.

Transferable courses that have not been deemed equivalent are up to the student's department to apply to degree requirements as they see fit. These courses are reviewed by the CEAE Department's Faculty Transfer Credit Evaluator. The CVEN undergraduate academic advisor prepares a transfer credit evaluation for each transfer student, showing how all transfer coursework is being applied to degree requirements. This form is signed by the Faculty Transfer Credit Evaluator and kept in the student's file.

Current CVEN students who want to take a transfer course (typically over the summer) can also use Transferology, or ask the CVEN undergraduate academic advisor if the course has been reviewed for equivalence. If not, students are encouraged to have the course reviewed in advance to ensure that it will be accepted. Pre-approval for these courses is also handled by the CEAE Faculty Transfer Credit Evaluator.

Internal Transfers

Internal transfer applicants (degree-seeking students from another college/school at the CU Boulder campus) are admitted by the College, either via the Pre-Engineering Program or the Intra-University Transfer (IUT) process.

The IUT process allows CU Boulder students to transfer into the College if they complete a set of requirements which demonstrate their ability to be successful in an engineering curriculum. As with external transfers, IUT students must complete a minimum of two semesters of calculus and two semesters of science. CU cumulative and technical GPAs of at least 2.7 are required. The full set of IUT requirements is posted at http://www.colorado.edu/engineering-advising/transfer-within-cu.

The Pre-Engineering Program is a specialized IUT program serving qualified students who initially applied for direct admission to the College of Engineering and Applied Science, but were alternatively offered admission to the College of Arts and Sciences. The program is designed to facilitate the successful transition of qualified first-year students into the College. The program provides a structured pathway of CU Boulder coursework combined with academic advising support from both the College of Engineering and Applied Science and the College of Arts and Sciences.

Pre-Engineering students are generally required to complete the same IUT requirements in order to transfer into the College. The program requirements are posted at http://www.colorado.edu/pre-engineering/how-pre-engineering-works. However, Pre-Engineering students also have an accelerated transfer option, for students who earn cumulative and technical GPAs of 3.3 or higher in their first semester and meet the other requirements posted at http://www.colorado.edu/pre-engineering/how-pre-engineering-works/step-3-transferring-engineering/accelerated-transfer-option.

D. Advising and Career Guidance

Advising in the College of Engineering and Applied Science is a shared responsibility between our professional staff advisors and our faculty mentors. While there are some differences between programs in their approach to advising, most of the programs employ staff advisors to assist students in planning their schedules and tracking their progress towards a degree. Faculty mentors provide career advice and guide students towards particular electives depending upon their interests and future plans. Students are also encouraged to consult with faculty from the Herbst Program of Humanities as they select their elective courses in the humanities and social sciences.

The College of Engineering and Applied Science understands the importance of good advising. Undergraduate advisors have been meeting monthly since July 2004 to share best practices and identify ways in which the College can support and improve advising. A collection of best practices and advising tools has been developed to support current advisors, and for use in training new advisors. The College annually recognizes exceptional advisors with an Outstanding Faculty Advisor Award and an Outstanding Staff Advisor Award.

Christina Vallejos is a staff member (non-faculty) who serves as the full-time Undergraduate Advisor for the Bachelor of Science students in Civil Engineering. She is the primary point of contact for students, advising students on general matters including curriculum, schedule, prerequisites, general requirements, graduation certification, etc. She meets individually each semester with first and second year students to plan their courses for the next semester, as well as to discuss their overall degree plans (including minors, certificates, study abroad, etc.). Standard additional topics include: independent study, research opportunities, concurrent BS/MS, double majors, additional majors, minors, study abroad planning, and graduate school. Tutoring and special student help, academic probation, suspension may also be a part of this discussion. Students are not allowed to register for classes without first meeting with the Undergraduate Advisor to have an advising hold removed. Many students additionally avail themselves of walk-in hours and specially-scheduled appointments.

CVEN underclassmen also have access to faculty advising if needed. If students have questions or need advice beyond the scope of the staff advisor, they will be referred to an appropriate faculty member. The CVEN Faculty Director serves as the default faculty advisor for these students, but students may be referred elsewhere if they have questions relating to a particular faculty member's area of expertise.

As juniors, civil engineering students are assigned a faculty advisor. Students may change to another advisor with approval from the new advisor. From this point forward, the student meets with their faculty advisor for mandatory advising each semester. This meeting is scheduled by the student during a designated two-week advising period and is 20 minutes long. The advising program is such that faculty make extra time available during these two weeks, so that all students are accommodated. Students bring their departmental file to the advising session so that both student and faculty advisor have the most current information. Typically, the curriculum block diagram is annotated to show student progress and current status. Faculty advisors give students advice in selecting proficiency courses, which CEAE technical electives match a student's career goals, etc. Faculty advisors also give students career advice, answer questions on graduate school, etc. Students are required to meet with their faculty advisor each semester prior to having a course registration hold removed by the undergraduate advisor. The students may also meet with the staff advisor on an as-needed basis, typically related to administrative issues (petitions, independent study agreements, or other paperwork). In addition, the staff advisor conducts a final graduation meeting with each graduating senior civil engineering student to review graduation processes and deadlines.

The staff advisor also conducts individual meetings with all students placed on academic alert or academic recovery. The purpose of these meetings is to make sure the student understands the requirements they must meet to return to good academic standing, discuss factors affecting the student's academic performance, and provide guidance, resources, and/or referrals to other academic support services.

All students are encouraged to meet with Career Services counselors early on and are notified of all Career Services events, such as resume critiques, interviewing practice sessions, career fairs, etc. Other internship and job opportunities in the form of information sessions, on-campus recruiting and tech talks are shared with our students as well. In addition to the generalists in the central Career Services office, two professional staff members are housed in the College, dedicated to providing more specialized assistance in career and professional development, identifying internships, advocating co-op programs, designing engineering-specific career development programs, liaising with employers, and answering questions. The department hosts its own CEAE career fair in fall and spring semester. This helps students connect with summer internships and post-graduation employment. For more information, see http://www.colorado.edu/career/.

In addition to academic support programs offered by the campus (e.g., Student Academic Services Center, Department of Housing Academic Support Program, Office of Disability Services), the College of Engineering and Applied Science provides several substantial academic support programs. Among these are the Peer Advocates peer-advising program, the Engineering Fellows Program, and advising and tutoring offered by the Broadening Opportunity through Leadership and Diversity (BOLD) Student Success Center. For more information on these programs, see http://www.colorado.edu/engineering-advising/resources-support/academic-support-tutoring.

E. Work in Lieu of Courses

University and College policy on awarding credit for work in lieu of courses is summarized here:

Advanced Placement (AP) Examinations
College credit may be granted on the basis of the College Board's Advanced Placement tests, for students who have taken an advanced placement course in high school and who make the required score in the College Board's Advanced Placement examination. See the AP Chart at http://www.colorado.edu/admissions/undergraduate/apply/freshman/credit to determine what examination score is required to earn CU-Boulder Course Equivalent college credit.

International Baccalaureate (IB) Examinations
College credit may be granted for approved IB examinations with minimum scores. See the International Baccalaureate Chart at http://www.colorado.edu/admissions/undergraduate/apply/freshman/credit to determine what examination score is required to earn CU-Boulder Course Equivalent college credit.

College-Level Examination Program (CLEP)
Credit for College Board subject examinations of the College-Level Examination Program (CLEP) in general biology, general chemistry, general psychology, introductory macroeconomics & microeconomics, introductory sociology, and calculus may be granted for a score at or above the 67th percentile. CLEP general examinations are not accepted for credit at CU-Boulder.

Military Credit
Credit for military schooling is evaluated upon receipt of Form DD 214, Service Separation Certificate, or the Joint Services Transcript (JST). Only work that has received an upper-division baccalaureate recommendation by the American Council on Education (ACE) can be awarded credit. This work, however, is transferred and recorded at the lower-division level. Foreign language credit taken through the State Department, Department of Defense, or Defense Language Institute is assigned the recommended ACE credit.

F. Graduation Requirements

The Bachelor of Science in Civil Engineering (2016) consists of courses from 5 major areas:

- Civil Engineering (59 credit hours)
    - Engineering science courses – 18 credit hours
    - Civil engineering fundamental courses in five areas – 15 credit hours
    - Civil engineering proficiency courses – 9 credit hours
    - CEAE technical electives – 6 credit hours
    - Senior capstone design – 4 credit hours
    - Miscellaneous – introduction, drawing, geomatics, professional issues – 7 credit hrs
- Natural and Basic Science (17 credit hours)
- Mathematics (16 credit hours)
- Basic introductory course to computing (3 credit hours)
- Technical electives (9 credit hours) - from engineering, math, and/or natural sciences
- Humanities and Social Sciences (18 credit hours) – including writing
- Free electives (6 credit hours) to make the required 128 credit hours.

To be eligible for the baccalaureate degree from the College of Engineering and Applied Science on the Boulder campus, a student must meet all of the following minimum requirements:

1. The satisfactory completion of the prescribed and elective work in the Civil Engineering BS curriculum as determined by the CEAE Department. A student must complete a minimum number of semester hours, not less than 128, of which the last 45 must be Boulder coursework earned after admission to the university and this college.
2. A University of Colorado cumulative GPA of 2.250 (2.000 for new students pre-Fall 2011) for all courses attempted.
3. A cumulative GPA, separately computed, of 2.250 (2.000 for new students pre-Fall 2011) in courses taken from the CEAE department is also required.
4. The satisfactory completion of all Minimum Academic Preparation Standards (MAPS) deficiencies.

5. Successful completion of WRTG 3030, Writing on Science and Society, or an approved alternative writing course (HUEN 1010, HUEN 3100, WRTG 3035, or PHYS 3050). Any exceptions to the WRTG 3030 requirement must be approved via petition by the Assistant Dean for Students.
6. Completion of the Fundamentals of Engineering (FE) Examination during the student's senior year. Graduation is not contingent upon passing.
7. Submission of a completed graduation application, online via MyCUInfo.

Students meet with their academic advisor to discuss progress towards degree requirements, and then if appropriate, apply for graduation via the online Student Center according to the timelines posted on the Registrar's website (http://www.colorado.edu/registrar/students/graduation).

The CEAE department reviews individual student records and utilizes degree audits to confirm baccalaureate degree requirements have been met. After the Undergraduate Advisor for Civil Engineering verifies that degree requirements will be met, faculty members on the Operations Committee also review each student's file. A Confirmation of Graduates Meeting is convened by the Assistant Dean for Students of the College with the purpose of approving a certified list of graduates by representatives of degree-granting departments and programs following the close of the fall and spring semesters and the final summer term.

G. Transcripts of Recent Graduates

The program will provide transcripts under separate cover as supplemental materials. The transcript specifies Bachelor of Science, Civil Engineering. For each student transcript, we will provide a degree audit, as well as a curricula guide for the Civil Engineering degree.

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

A. Mission Statement

The University of Colorado Boulder (CU) is a "comprehensive graduate research university with selective admissions standards . . . offer(ing) a comprehensive array of undergraduate, master and doctoral degree programs" (http://www.colorado.edu/about/mission) CU established a vision to "be a leader in addressing the humanitarian, social and technological challenges of the 21st century." (http://www.colorado.edu/chancellor/strategic-plan) With three strategic imperatives to shape tomorrow's leaders, be the top university for innovation and positively impact humanity.

The mission of the College of Engineering & Applied Science is:

> The college's mission is to generate new knowledge in engineering and related fields, and to equip students from diverse backgrounds to become leaders and citizens responsible for the betterment of individuals and society.
> (http://www.colorado.edu/engineering/about/mission-vision)

"The Civil, Environmental and Architectural Engineering Department's mission is the education of undergraduate and graduate students to become leaders in the professional practice of engineering, contributing to technological advances that benefit humankind while enhancing the earth's physical and biological resources." (http://www.colorado.edu/ceae/about-us)

B. Program Educational Objectives

The program objectives for the bachelor of science degree in civil engineering are that within five years:

1. Graduates will be successfully employed in engineering, science, or technology careers
2. Graduates will be assuming management or leadership roles
3. Graduates will engage in continual learning by pursuing advanced degrees or additional educational opportunities through coursework, professional conferences and training, and/or participation in professional societies
4. Graduates will pursue professional registration or other appropriate certifications
5. Graduates will be engaged in activities that provide benefit to communities

These objectives are published on the departmental website:
http://www.colorado.edu/ceae/about/undergraduate-degrees/educational-objectives-outcomes?qt-quicktab_educational_outcomes=1#qt-quicktab_educational_outcomes

The objectives are also published in the University of Colorado catalog:
http://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/civil-engineering-bachelor-science-bs/

C. Consistency of the Program Educational Objectives with the Mission of the Institution

The overall themes in these institutional mission statements include the education of professionals who exhibit technological knowledge, leadership, and responsible citizenship; these are also reflected strongly in the educational objectives of the Civil Engineering program.

D. Program Constituencies

The primary constituents of the CVEN program are the students and alumni of the program, and the employers of our graduates. The departmental faculty members are also a constituency.

The CVEN students and alumni are served through the program objectives by having employable skills that will help them find and advance in rewarding careers, building from their foundational skills in civil engineering. The alumni are invited to provide feedback to the program objectives formally via the online alumni survey distributed each summer. Alumni about five and/or eight years after earning their Bachelor's degree are invited to participate in the alumni survey.

Employers of our graduates are served through the program objectives by having employees with competence and commitment to keeping their technical skills up-to-date.

Alumni and employers of our graduate are invited to serve on advisory boards (i.e. the Joint Evaluation Committees, JECs) through which they can review and provide additional input to the educational objectives.

The departmental faculty members can use the program objectives to guide their teaching and mentoring activities of civil engineering students moving through the program. The faculty have the ability to revise these objectives if they believe that they are no longer serving CVEN students, alumni, and the engineering profession.

E. Process for Review of the Program Educational Objectives

There are two primarily mechanisms that review the program educational objectives, and provide input into revisions. First, the Joint Evaluation Committee (JEC) process reviews the educational objectives and the associated feedback from alumni. Each JEC is comprised of program constituencies: practicing, professional engineers who are employers of our graduates and/or program alumni; one or more current students; and departmental faculty representatives. Typically, one or two JECs meet each academic year (see Table below). Each JEC focuses on a sub-discipline area (construction engineering and management, environmental and water resources, geotechnical engineering, structural engineering and mechanics). Each JEC reviews the program educational objectives. JECs for each sub-discipline reconvene every 3 years. The

JECs that have met since the last ABET review are summarized below. The JECs are required to review the educational objectives and recommend changes.

Focus	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Construction Engineering and Management			X			X
Environmental and Water Resources	X			X		
Geotechnical			X			X
Structural Engineering & Mechanics		X			X	

Second, alumni have formal input into the program objectives through an alumni survey instrument. Each summer, alumni five years (and recently also eight years) after graduation are asked to evaluate the appropriateness and their accomplishment of the program objectives. The feedback from the alumni is provided to the JECs for their consideration.

All constituents also have informal but important input through ongoing contacts with the program faculty. Potential changes to the program objectives arising from input from program constituents or assessment information are discussed and approved by the civil engineering faculty. The discussion process is often facilitated via the departmental curriculum committee, which has representatives from the major faculty groups in the department. The potential changes are also discussed by the faculty at large and must be approved by a majority vote.

Most recently, during the 2014-2015 academic year, the CEAE faculty voted to revise the fifth program objective. Objective 5 was previously: “Graduates will be active in civic engagement.” JEC feedback indicated that the wording was vague and unclear. Alumni also indicated lower agreement that this outcome was appropriate, relative to the other program outcomes on the annual alumni survey. Thus, “civic engagement” was revised to “activities that provide benefit to communities.”

CRITERION 3. STUDENT OUTCOMES

A. *Student Outcomes*

The outcomes that students are expected to have attained upon graduation with a bachelor of science degree in civil engineering are listed below; mapping to the ABET (a) to (k) Student Outcomes are shown in brackets:

1. [a] the ability to apply knowledge of mathematics, science and engineering
2. [b] the ability to design and conduct experiments
3. [b] the ability to analyze and interpret data
4. [c] the ability to design a system or component to meet desired needs
5. [d] the ability to function on multidisciplinary teams
6. [e] the ability to identify, formulate and solve engineering problems
7. [f] an understanding of professional and ethical responsibilities
8. [g] the ability to communicate effectively through writing and/or drawing
9. [g] the ability to communicate effectively through oral presentations
10. [h] an understanding of the impact of engineering on society
11. [i] an understanding of the necessity to engage in life-long learning
12. [j] a knowledge of contemporary issues in civil, environmental and architectural engineering
13. [k] the ability to use modern engineering techniques, skills and tools
14. the ability to explain basic concepts in management, business, public policy and leadership

These outcomes have remained consistent since the previous ABET review.

These objectives are published on the departmental website:
http://www.colorado.edu/ceae/about/undergraduate-degrees/educational-objectives-outcomes?qt-quicktab_educational_outcomes=1#qt-quicktab_educational_outcomes

The objectives are also published in the University of Colorado catalog:
http://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/civil-engineering-bachelor-science-bs/

B. *Relationship of Student Outcomes to Program Educational Objectives*

The civil engineering program objectives map to the 14 student outcomes of our program, as shown below where an “x” indicates that the accomplishment of the related outcome is an important ingredient for accomplishing the objective. The figure illustrates that four of the five objectives are linked to two or more outcomes, so that processes that are used to assess the outcomes indirectly help to ensure that the overall objectives are being accomplished. Philosophically, consistency between the civil engineering program objectives and the general educational outcomes for engineering students is desirable for ensuring the professional success of our graduates.

Mapping of Student Outcomes to the Program Objectives

	Student Outcomes													
Program Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Graduates will be successfully employed in engineering, science, or technology careers	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2. Graduates will be assuming management or leadership roles					x									x
3. Graduates will engage in continual learning by pursuing advanced degrees or additional educational opportunities through coursework, professional conferences and training, and/or participation in professional societies											x			
4. Graduates will pursue professional registration or other appropriate certifications							x				x			x
5. Graduates will be engaged in activities that provide benefit to communities							x			x		x		x

CRITERION 4. CONTINUOUS IMPROVEMENT

A. Student Outcomes

Outcomes Assessment Methods Summary

The table below provides a summary of the multiple direct and indirect methods that are used to assess achievement of each of the student outcomes. Not all methods are used for all outcomes. The highlighting in green indicates that the outcomes have been consistently met at a sufficient level. Yellow indicates variable fulfillment and/or marginal fulfillment of the outcome based on the metric in question. Red indicates that we failed to meet our goal for that indicator of the outcome. Each of the assessment methods is described in more detail in the paragraphs below.

The FE exam is the national NCEES Fundamentals of Engineering exam. It is a direct evaluation method that is used to assess 7 of the 14 student outcomes. All CU CVEN students are required to take the exam before they graduate; they typically take the exam one of their last two semesters. Data are provided from the NCEES summarizing the performance of our students twice per year (approximately January and July). The FE exam topics have been mapped to our student outcomes. Outcomes are flagged as a concern if CU students have a ratio score on the topic of interest relative to national CVEN students at 0.92 or lower (with the old exam format, the threshold for concern was performing 5% or more below the national average for CVEN students). Data highlights including the overall pass rate and any weaknesses identified are presented to the CEAE faculty at an at-large meeting once per semester. Any problems are also discussed by the curriculum committee.

The capstone design course offers an opportunity to evaluate the cumulative knowledge of the students with respect to many of the outcomes. An assessment rubric has been consistently employed in the capstone senior design course (since Fall 2010) to directly assess several of the outcomes based on the team design reports and oral presentations. The rubric developed was based on other published rubrics, and produces scores of 1 to 4 on various items (poor, needs improvement, adequate, and superior). Our target is that 80% or more of the team reports and/or individual assignments should score at an adequate or better level. Multiple faculty (generally four) grade the team project deliverables, while graduate students, serving as teaching assistants (TAs), score the individual homework assignments. The specific rubric used will be presented below with the evidence for each student outcome. There were also additional individual assignments/quizzes used for evidence of achievement of some student outcomes; these were largely replaced with direct assessments from assignments in the new Professional Issues course, starting in Fall 2016.

Within specific courses, various assignments (or questions on assignments), projects, lab write-ups, or exams are used as embedded indicators to directly measure student learning of some outcomes. Frequently, the normal grades on a particular assignment or question on an assignment are converted to a four-point scale, where: superior = 90% or more, adequate = 80%-90%, needs improvement = 70-80%, and poor = below 70%. The target is for 80% or more of our students to be rated adequate or above on each embedded indicator. These data are presented to the JEC for evaluation, and the JECs often directly examine student work during their assessments. Thus, the JEC feedback can also be considered a direct assessment.

Student Outcomes Assessment Methods: Summary [N/A = not applicable]

CU CVEN Student Outcomes [ABET A-K]	FE exam	Design course	Other course direct assessment / JEC review	Student FCQ ratings, avg top 3	Senior survey avg. rating
1. apply knowledge of math, science, & engineering [a]	5 topics	N/A	College-wide panels for service courses	5.0	4.2
2. design & conduct experiments [b]	N/A	N/A	CV3161, 3323, 3708	4.5	3.7
3. analyze and interpret data [b]	statistics	N/A	CV3323, 3708, 3227	5.1	4.2
4. design a system or component to meet desired needs [c]	N/A	Final report	CV3323; Proficiencies	5.2	4.0
5. function on multi-disciplinary teams [d]	N/A	Peer eval	CV1317, 2012, 3246, 3323	5.0	4.2
6. identify, formulate, and solve engrg problems [e]	5 CVEN topics	N/A	Most courses	5.2	4.2
7. professional and ethical responsibilities [f]	ethics	Individual Quiz*	CV1317, 3246, 3414, 4897	5.0	3.9
8. communicate by writing and/or drawing [g]	N/A	Final report	WRTG3030; CV1317, 3246, 4899	4.5/4.8	3.7/3.6
9. oral communication [g]	N/A	Presentn	CV3246, 3414, 4899, (CV3698)	4.6	3.6
10. impact of engineering on society [h]	N/A	Individual Quiz*	CV1317, 3246, 3414, 4897	5.1	4.0
11. necessity to engage in life-long learning [i]	Overall FE pass rate	Individual Quiz*	CV1317, 3246, 3323, 4897	4.8	4.0
12. knowledge of contemporary issues [j]	Eng. economics	Individual Quiz*	CV1317, 3246, 3414, 4897	4.8	3.5
13. modern engrg techniques, skills, tools [k]	computers	Final report	CV2012, 3223, 3525	4.9	3.7
14. management, business, public policy, leadership	N/A	Individual Quiz*	CV3246, 4897	5.1, 4.6, 4.7	3.4

** Performance on questions related to this topic were not routinely recorded as distinct from the other topics on the quiz; we are thus unable to assess this outcome individually*

Two indirect assessment methods are also used to evaluate each of the 14 student outcomes. First, at the end of each semester, CU students are asked to evaluate the extent to which each of the CVEN undergraduate courses contribute to their achievement of the 14 student learning outcomes. These are questions that have been added to the university-wide Faculty Course Questionnaires (FCQs) that are administered by the campus. We expect that student ratings (on a scale of *not applicable = 0* to 6) should be 4 or higher for a minimum of three or more required courses. These data for relevant courses are presented to the JECs. Data from selected courses targeted for each outcome are presented for each outcome in the following sections. Each academic year, the data from required courses are compiled in a spreadsheet to ensure that our targets are being met. In addition, the student evaluation data are compared to faculty ratings of how their courses contribute to the learning outcomes.

The second indirect assessment method used to evaluate each of the 14 student outcomes is the senior survey. The senior survey is administered by the College of Engineering & Applied Science three times per year. Students graduating in spring, summer and December are emailed invitations to participate in the survey, which is administered via the online package Qualtrics. Response rates are typically very high (over 90%) for CVEN students. In one section of the survey, students rate their achievement of all the 14 student outcomes, using a scale of 1 to 5. Achievement should be rated at 3.5 or higher to be satisfactory. The college previously returned data twice per year; it now combines the data for an academic year into a single report. The 2016/2017 graduates data is not included, since due to quality checks it is not expected to be distributed to departments until September/October (following the historical schedule). The senior survey data are presented to the JECs for evaluation. They are also examined and summarized in an annual report written by the Assessment Coordinator (Bielefeldt) and reviewed by the Department Chair, and then posted on the College assessment website.

The data for each outcome will be presented in detail in the following sections.

Outcome 1. [a] Apply knowledge of math, science, and engineering fundamentals

Outcome 1 [a]: FE exam

Direct assessment of this outcome is largely conducted by student performance on the NCEES Fundamentals of Engineering (FE) exam. Since the revision of the exam in January 2014 from an 8-hour format to a ~5 hour online format, we have decided to rely on five topics to evaluate this outcome: math, statics, dynamics, fluids, and mechanics of materials. Ratio scores are reported, representing the ratio of the average percentage of questions on a topic that CU CVEN students answer correctly divided by the average percentage of questions on a topic that CVEN students nationally answer correctly. Academic year weighted averages are reported, since some semesters have a low number of test takers. The goal is to exceed a ratio score of 0.92. We successfully met this goal for all topics individually. Green highlights indicate where on average CU students performed better than their peers nationally. Averaged across the five topics, CU CVEN students performed at or above national CVEN peers. Thus no deficiency is evident.

Academic Year/Term:	Sp 14	F2014-S15	F2015-S16	F2016
n	*16*	*36*	*52*	*14*
FE Exam Topic	**Ratio Scores of CU performance vs. National**			
Math	.97	.98	.99	1.03
Statics	.97	.95	.99	.93
Dynamics	1.17	1.05	1.09	1.02
Fluids	1.15	1.11	1.01	1.18
Mechanics Materials	1.00	.93	.99	.93
Average Outcome 1	**1.05**	**1.00**	**1.01**	**1.02**

Previously, with the old format of the FE exam we used student performance on seven topics to assess students' ability to apply knowledge of math, science, and engineering fundamentals. These were topics on the morning part of the exam. The average percentage of questions on each topic that CU CVEN students answered correctly was compared to the average for CVEN students nationwide; the difference is shown. If the CU students were not more than 5% below their national peers, the performance was considered acceptable. All instances were acceptable. There were two topics where CU student performance was of concern (at -3% to -5%) in one or more years (highlighted in yellow): statics, and strength of materials. However, in most cases the average performance of CU CVEN students on the topics exceeded their national peers (highlighted in green). Averaged across the seven FE topics of interest, in all evaluation cycles we met and exceeded our goal. The results show that CU students are adequately able to apply knowledge of math, science, and engineering fundamentals.

Academic Year/Term:	F2011-S12	F2012-S13	Fall 2013
n	*98*	*92*	*56*
Topic on the FE exam	**CU % correct – Natl % correct**		
Math	9	5	5
Chemistry	1	-1	5
Statics	-4	0	2
Dynamics	3	3	2
Strength Materials	0	-3	-5
Electricity & Magnetism	3	-1	2
Fluid mechanics	3	5	3
Thermodynamics	2	9	6
Average Outcome 1	**2**	**2**	**3**

Outcome 1 [a]: Courses

Many of the service level courses taken by CVEN majors along with most other engineering majors build the foundation for this outcome: Calculus 1, 2, 3; Linear Algebra and Differential Equations; Chemistry for Engineers; General Physics 1; General Physics 2; Experimental Physics I. These courses are required for many different engineering majors and are therefore reviewed by specially convened "Task Forces" as part of the CEAS Undergraduate Education Council.

A review of the calculus courses through Applied Math (APPM) was conducted in 2014-2016, with a number of math surveys conducted. The students who pass through the calculus sequence have strong knowledge and competency. The concern is the high percentage of students who are not passing these courses on the first try. No deficiency related to calculus knowledge is evident.

A review of the physics laboratory course PHYS 1140 Experimental Physics I was conducted in 2016. Wil Srubar from CEAE served on the committee. The committee reviewed feedback from a special faculty survey on the course and feedback from CEAS students via the senior survey and mid-curriculum survey. The committee developed recommendations for course content and delivery. The course quality is deemed to be high, but with student concerns centering around workload and mathematical derivations related to uncertainty and error analysis. No deficiency related to physics knowledge was evident.

In 2014, a response was submitted to the chemistry review committee's 2010 report. Prof. Joe Ryan from CEAE served on the chemistry review committee. The review concerns did not relate to a lack of student knowledge upon passing the course, but rather the generally poor student experience in the course. Course changes included smaller lecture site, a recitation, incorporation of active learning, and on-line homework. No deficiency related to basic chemistry knowledge was evident.

In addition, almost all CVEN courses also include this outcome to some extent, since math and science fundamentals are being applied. Given the strength of direct assessment via the FE exam, additional direct assessment evidence is not gathered to assess this outcome.

Outcome 1 [a]: JEC Review

The JECs have not noted any weaknesses in the areas of math, science, and engineering knowledge.

Outcome 1 [a]: Student Ratings on Course FCQs (0-6)

This outcome had the second highest overall average rating by students across all of the required courses in the civil engineering curriculum, averaging 4.7 across all courses and all semesters of data. In all, 11 required courses were consistently rated at or above 4.0 for an average student rating. Therefore, the student FCQ ratings indicate no weaknesses in this outcome. The table below presents average student ratings for four representative courses – three engineering science courses and one CVEN fundamental course. Three of the courses were offered both fall and spring semesters, so two sets of FCQ values per year are shown.

Math, Science, Engineering Outcome: Average Student Ratings on Course FCQs (0-6 scale)

Academic Year	CVEN 2121 Analytical Mechanics 1	CVEN 3161 Mechanics of Materials 1	CVEN 3313 Fluid Mechanics	CVEN 3525 Structural Analysis
2011-12	5.2, 4.0	5.1, 5.0	5.4	5.3, 4.2
2012-13	N/A, 4.7	N/A, 5.1	4.7	N/A, 4.7
2013-14	5.2, 4.8	5.1, 5.6	5.4	5.1, 5.0
2014-15	4.6, 5.3	4.4, 5.5	4.3	5.1, 5.1
2015-16	5.3, 5.6	5.3, 5.6	5.5	5.5, 3.5
2016-17	5.0, 4.6	4.9, 4.0	5.3	4.4, 5.6

N/A = the university left the question off the FCQ form that term

Outcome 1 [a]: Senior Survey

On the survey distributed to all graduating senior students, students are asked to rate their personal achievement and the importance of the outcome "ability to apply knowledge of math, science, and engineering" using a Likert-scale from 1 to 5. These achievement and importance ratings all exceed 3.5 and indicate no weaknesses for this outcome.

Senior Survey Avg rating 1-5 scale	Year	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*56*	*77*	*85*	*59*	*60*
Math, Science, and Engineering		4.0	4.2	4.3	4.4	4.2

<u>Summary</u>: All of the direct and indirect assessment measures met our targets in each academic year. Therefore, this outcome has been sufficiently achieved.

Outcome 2. [b] Design and Conduct Experiments

Outcome 2 [b] Course Direct Assessments

The three primary required CVEN courses with laboratory experiments are: CVEN 3323 Hydraulics, CVEN 3708 Geotechnical Engineering 1, and CVEN 3161 Mechanics of Materials 1. The student grades on the final lab report of the semester were used to indicate adequate ability to design and conduct experiments (and analyze and interpret the data), as evidenced in these courses. Example data are shown below. Each professor determined the rubric and criteria for scoring the lab reports. In general, 90% and above was considered superior, 80-90% adequate, and less than 80% below adequate. The goal is to have these lab grades serve as embedded indicators of students' abilities to design and conduct experiments. These data are compiled from the most recent semester in advance of the JEC and the lab, scoring rubric, and examples of student work from each level presented to the JEC for review (Mechanics of Materials to the structures JEC, Hydraulics to the Water and Environmental JEC, and Geotech 1 to the geotechnical engineering JEC). For CVEN 3161, the performance of the CVEN students was tracked separately from Architectural Engineering (AREN) students in 2014-2017, who also are all required to take CVEN 3161.

Design and Conduct Experiments: Student Performance on Laboratory Portion of Course

Course	Term	# *students*	% below adequate	% adequate	% superior
CVEN 3161 Mechanics of Materials 1 (spring used for evaluation recently due to larger enrollment)	Sp 2017	*47*	4	4	91
	Sp 2016	*47*	0	2	98
	Sp 2015	*37*	0	8	92
	Sp 2014	*43*	0	19	81
	F 2014	*35*	6	6	89
	F 2013	*34*	0	11	89
	F 2012	*52*	2	17	81
	Sp 2012	*90*	3	24	72
	F 2011	*40*	33	37	30
CVEN 3323 Hydraulics (course only offered in fall term)	F 2016	*69*	7	16	77
	F 2015	*75*	1	19	80
	F 2014	*80*	11	6	83
	F 2013	*63*	22	43	35
	F 2012	*96*	0	0	100
	F2011	*92*	11	26	63
CVEN 3708 Geotech 1	Sp 2017	*15*	20	13	67
	F 2016	*48*	8	21	71
	Sp 2016+	*20*	10	45	45
	F 2015	*44*	0	20	80
	Sp 2015	*23*	40	30	30
	F 2014	*60*	15	38	47
	Sp 2014	*34*	17	12	71
	Sp 2013+	*36*	8	44	48
	Sp 2012	*43*	14	49	37

+ instructor used B and C grades as adequate

For example, the final laboratory of CVEN 3323 Hydraulic Engineering involved a lab on weirs. The students' lab grades are based on the following items:

Participation in the laboratory experiment (grade of zero for not attending the lab)

Written report of the experiment including

- Presentation of raw data
- Sample calculations
- Results, including error analysis (tables of numerical values and plots of results)
- Discussion of results (via answers to specific questions)
- Professionalism of report

For these three required sophomore/junior courses with a lab component, the data indicate sufficient fulfillment of this outcome, since >80% of the students possessed an adequate ability to conduct the experiments in 21 out of 24 semesters.

Outcome 2 [b] JEC

The JEC process often focuses significant attention on laboratory based courses, including review of student work. No deficiencies related to the current abilities of the students to design and conduct experiments on the basis of CVEN 3161, CVEN 3323, or CVEN 3708 were noted.

Outcome 2 [b] Student Course FCQs

At the end of the semester the students rate the extent to which the course improved their ability to design and conduct experiments; data for the three required courses in the curriculum with high ratings are summarized below. Some large variation in the responses between semesters is evident, which appears primarily driven by the course instructor (lower instructor and course overall FCQ ratings corresponding to the lower outcome ratings); 25 of 30 semesters the goal was met. Each of these three classes have average ratings above 4 in each year, indicating adequate coverage.

Design and Conduct Experiments Outcome: Student Ratings on Course FCQs (0-6 scale)

Academic Year	CVEN 3161 Mechanics of Materials 1	CVEN 3323 Hydraulics	CVEN 3708 Geotechnical Engineering 1
2011-12	3.5, 4.3	4.5	4.9, 4.5
2012-13	4.0, 4.3	4.5	5.4, 5.0
2013-14	3.8, 4.3	4.9	5.0, 5.0
2014-15	3.7, 4.4	4.8	4.2, 4.9
2015-16	5.0, 4.5	5.0	3.6, 5.1
2016-17	4.6, 3.6	5.0	5.0, 4.0

Outcome 2 [b] Senior Survey

The seniors consistently rated their personal achievement of the ability to design and conduct experiments at an adequate level (3.5 or higher), as shown in the table below.

Senior survey Avg ratings 1-5 scale	Year	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*56*	*77*	*85*	*59*	*60*
Design and conduct experiments		3.5	3.8	3.8	3.9	3.7

Summary: The indirect assessment methods are the weakest data in terms of meeting our goals, but while sometimes marginal they did not fail to meet our minimum criteria. Given the totality of the direct and indirect assessment data, the students are sufficiently meeting the outcome to design and conduct experiments.

Outcome 3 [b]. Analyze and Interpret Data

Outcome 3 [b] FE Exam

Student performance on the NCEES Fundamentals of Engineering exam on the topic of probability and statistics is an indicator of our students' abilities to analyze and interpret data. On the old format of the exam, CU CVEN students performed above national CVEN students (thus, highlighted in green). From the online format of the FE exam, CU students are performing below national peers, but within acceptable levels (above ratio scores of 0.92).

FE topics	Year	11-12	12-13	F13	Sp14	14-15	15-16	F16
	n CU students	*98*	*92*	*56*	*16*	*36*	*52*	*14*
Probability & statistics	Ratio score				0.96	0.95	0.98	.97
	% Difference	*4*	*9*	*3*				

Outcome 3 [b] JEC

Only one JEC commented on students' abilities to analyze complex data sets. The 2012 water resources & environmental JEC indicated that given CVEN 3227 was in the sixth semester of the curriculum and some students delay the course until their final year, there is little opportunity for students to apply the knowledge gained in the course. Further, the focus of the course is predominantly on probability and risk, rather than statistical analyses. Since that time, additional focus on application of data analysis has been added into the water resources proficiency course, hydrology.

Outcome 3 [b] Student Ratings on Course FCQs

Students are expected to analyze and interpret data in a number of required CVEN courses. The students' ratings for the four courses with the most content related to this outcome are summarized below. Students gave strong ratings to all four courses, routinely rating this outcome above 5 in two of the courses. This is indirect evidence of fulfillment of this outcome.

Academic Year	CVEN 3227 Probability & Statistics	CVEN 3323 Hydraulics	CVEN 3161 Mechanics Materials 1	CVEN 3708 Geotechnical Engineering 1
2011-12	5.3	5.1	4.5, 5.0	5.1, 4.3
2012-13	5.1	5.0	4.6, 4.9	5.5, 5.0
2013-14	5.0	5.0	4.8, 5.3	5.2, 5.1
2014-15	5.3	5.3	4.2, 5.1	4.7, 4.8
2015-16	5.3	5.3	5.3, 5.1	3.7, 5.3
2016-17	5.0	5.6	4.8, 4.2	5.1, 5.2

Outcome 3 [b] Senior Survey

The ability to analyze and interpret data was one of the highest rated outcomes for achievement by graduating CVEN students, with achievement generally at or above 4.0. No weakness is evident from these data.

Senior survey Avg ratings 1-5 scale	Year	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*56*	*76*	*84*	*59*	*60*
Analyze & interpret data		3.9	4.2	4.3	4.3	4.3

Summary: In total, the direct evidence from the FE exam and indirect data from students' self assessments indicates that CU CVEN students graduate with sufficient ability to analyze and interpret data.

Outcome 4 [c]. Design a System or Component

Outcome 4 [c] Senior Design Rubric

Direct evidence of students' ability to design a system to comply with a variety of constraints and criteria is documented in the capstone senior design course. A rubric is used to evaluate the final team design reports for four aspects of design (see Appendix E). The table below presents the percentage of the senior capstone design team reports (each semester 8-19 teams each with 5-6 students) that were rated in each of the four categories of the rubric by four faculty reviewers. Some faculty used decimal scores, and these were allocated as: 3.6-4.0 superior, 3.0-3.5 adequate, 2.0-2.9 needs improvement, 1-1.9 poor. The goal was to have 80% or more of the student teams rated as adequate or higher in all four design categories; this target was achieved.

Design Outcome: Rubric to Evaluate Final Senior Design Reports

Sub topic	Year	Poor	Needs Improvement	Adequate	Superior
		1	2	3	4
		Percentage of Student Team Reports in Each Category			
Overall*	F2012	5	5	31	59
Ability to state the problem and constraints	F2013 F2014 F2015 S2016 S2017	0 0 0 0 0	1 0 6 9 0	17 18 19 25 20	82 82 75 66 80
Ability to compare and make selection between design alternatives	F2013 F2014 F2015 S2016 S2017	0 0 0 0 0	1 0 9 3 0	24 13 22 25 30	75 87 69 72 70
Multiple constraints and criteria appropriate to the design were considered	F2013 F2014 F2015 S2016 S2017	0 0 0 0 0	0 0 0 6 0	26 10 16 38 14	74 90 84 56 86
Ability to correctly complete a design	F2013 F2014 F2015 S2016 S2017	0 0 0 3 0	1 5 9 6 7	29 30 25 16 25	70 65 66 75 68

* In fall 2012 the instructor only logged overall design report grades on the final memo across the four sub-discipline areas

The senior design reports show that students have an adequate ability in design.

Outcome 4 [c] JEC

The only JEC to comment on design ability was the structures JEC in 2016. This included comments specific to structural design, in particular, application of the ACI and AISC codes in the reinforced concrete and steel design courses. They also included a recommendation to include outside industry involvement and industry mentors in the capstone projects. However, the design abilities of the students were not a direct concern.

Outcome 4 [c] Student Ratings on Course FCQs

Students were asked "The course improved my ability to design a system or process to meet desired needs." Design was highly rated by the students as an outcome in three required civil engineering courses and at least two of the proficiency courses that would be taken by all CVEN students (since design is strongly present in proficiency courses from four of the five sub-disciplines, every CVEN student will encounter design in at least 2 of the 3 proficiency courses that they take). The results indicate strong design content, with all students having at least three courses (Senior Design, Hydraulics, and a proficiency course) rated above 5.

Design Outcome: Student Ratings on Required Course FCQs (0-6 scale)

Academic Year	CVEN 4899 Sr Design	CVEN 3323 Hydraulics	CVEN 3246 Intro to Construction
2011-12	5.3	5.4	4.7, 4.8
2012-13	5.7	5.3	4.6, 5.1
2013-14	5.4	5.6	4.9, 4.8
2014-15	5.1	5.0	4.2, 4.7
2015-16	5.2, 5.3	5.5	5.0, 5.0
2016-17	5.6	5.6	5.1, 5.2

Student Design Ratings on Proficiency Course FCQs (students take 3 of 5; 0 to 6 scale)

Academic Year	CVEN 3424 Water/WW Tmt	CVEN 3718 Geotech Eng 2	CVEN 4333 Hydrology*	CVEN 3256 Constr Equip & Mt	CVEN 4545/55 Steel/Concrete Dsn
2011-12	5.6	4.2, 4.3	3.7	5.6	5.0, 4.7
2012-13	5.5	5.1, 4.9	3.5	5.2	5.3, 5.2
2013-14	5.5	4.6, 4.3	3.7	5.5	4.7, 5.2
2014-15	5.6	4.3, 4.0	3.2	4.6	5.4, 5.0
2015-16	5.7	5.2, 4.6	3.8	4.8	5.2, 5.1
2016-17	5.6	N/A, 4.8	3.5, 4.2	5.4	5.5, 5.8

* *As stated in the text, this proficiency course for water is not intended to include design*

Outcome 4 (c) Senior Survey

The senior survey included three questions related to design ability; results are summarized below. First the students rated their "ability to design a system, component or process to meet desired needs within realistic constraints", based on how well they individually achieved this outcome. The ratings are above 3.8 which indicate adequate fulfillment of this outcome.

The students also indicated their level of agreement (1-Strongly Disagree, 2-Disagree, 3-Neither Agree Nor Disagree, 4-Agree, 5-Strongly Agree) to two statements:

My (major) capstone/senior design project reinforced the concepts I learned in my College of Engineering education

My (major) capstone/senior design project prepared me for an engineering career

The senior responses to both questions show that students generally agree with these statements.

Senior Survey Avg ratings 1-5 scale	Year	2011-12	2012-13	2013-14	2014-15	2015-16
# responses		*56*	*77*	*85*	*58, 60*	*59*
Ability to design a system to meet desired needs		3.8	4.0	4.0	4.1	4.1
Senior design project reinforced the concepts I learned in engrg		4.0	4.1	4.0	4.0	3.8
Senior design project prepared me for an engineering career		3.8	3.9	3.8	3.9	3.6

Summary: The direct assessment data from capstone design is supported by the indirect assessment data, and demonstrates that the students have adequate abilities to design when they graduate.

Outcome 5 [d]. Multidisciplinary Teamwork

Outcome 5 [d] Senior Design Rubric

In the senior design course students work in teams all semester, with peer evaluations. The students rated their peers using criteria, originally developed from peer ratings used in CATME. CATME is the "Comprehensive Assessment of Team-Member Effectiveness." It is a peer-evaluation process that is behaviorally anchored, and has five sub-scales: contributing to the team's work (contribution), interacting with teammates (support), expecting quality (quality), keeping the team on track, and having relevant knowledges, skills, and abilities. The sub-categories for teamwork used in senior design varied somewhat each year. Teamwork element scores could range from 1 to 5. They were converted to rubric levels: <2.5 = poor; 2.5-3.49 = needs improvement; 3.5-4.49 = adequate; 4.5 or higher = superior. The minimum level for sufficient achievement of this outcome is that 80% or more of the students are adequate or higher on each aspect of teamwork. This goal was exceeded in each year.

Teamwork Outcome: Rubric for Evaluation in Senior Design Course

Year	Sub topics	Poor	Needs Improvement	Adequate	Superior
		1	2	3	4
		Percentage of Students in Each Category			
S2017	Overall teamwork	0	2	15	83
S2016	Contribution	3	3	21	74
	Attendance	3	3	13	82
	Support	3	3	13	82
F2015	Contribution	2	11	38	49
	Attendance	2	6	36	55
	Support/respect	0	9	19	72
	Quality	2	4	49	45
F2014	Overall teamwork	4	2	22	71
F2013	Contribution & Attendance	1	7	29	63
	Support	0	4	22	74

Outcome 5 (d) Student Ratings on Course FCQs

The ability to function on multidisciplinary teams was rated at 4 or higher in around 7 courses, although only intermittently in some of the courses; examples of the FCQ ratings are shown below. The most truly "multidisciplinary" experience occurs in the GEEN 1400 First Year Engineering Projects course, where each section includes students from all engineering majors. Civil and architectural engineering students work together on teams in CVEN 1317 Introduction to Civil Engineering (co-taught with AREN 1316 from 2012-2016), CVEN 2012 Geomatics, and CVEN 3246 Introduction to Construction. Civil engineering students work on teams with environmental engineering students in CVEN 3414 Fundamentals of Environmental Engineering. In the senior capstone design course, civil engineering students take on different roles in the project (structural, water resources, geotechnical, and construction). CVEN 3313 Hydraulics is only required for civil engineering students, so although teamwork is present, it is rarely multidisciplinary. In each year a minimum of three courses were rated at 4 or higher, so no deficiency in this outcome was found.

Multidisciplinary Teamwork: Student Ratings on Required Course FCQs

Academic Year	CVEN 1317 Intro CivilE	CVEN 2012 Geomatics	CVEN 3323 Hydraulics	CVEN3246 Intro Constr	CVEN 4899 Senior Design
2011-12	4.3	4.4	4.6	4.8, 5.3	5.5
2012-13	3.9	4.3	4.6	5.0, 4.9	5.7
2013-14	4.2	4.3	4.1	4.9, 5.0	5.3
2014-15	4.6	3.9	4.6	4.8, 4.9	5.2
2015-16	5.0	4.6	4.2	5.3, 5.1	5.0, 5.5
2016-17	4.1	4.4	4.9	5.1, 5.3	5.6

Outcome 5 [d] Senior Survey

The ability to function on a multidisciplinary team was rated at a sufficient level of average achievement by CVEN students, with ratings at or above 4.0. No weakness is evident from these data.

Senior Survey (avg ratings 1-5 scale)	Year	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*56*	*77*	*85*	*58*	*60*
Function on multidisciplinary team		4.0	4.3	4.4	4.3	4.1

Summary: The direct and indirect assessments provide sufficient evidence that our students reliably graduate with the ability to function on multidisciplinary teams.

Outcome 6 [e]. Identify, formulate, and solve engineering problems

Outcome 6 [e] FE Exam

Student performance on the FE exam on the five fundamental civil engineering topic areas that are taught within the CU CVEN curriculum were selected as a direct assessment to represent students' ability to solve engineering problems. Our goal is to be not more than 5% below the performance of national CVEN peers (when percentage correct was reported on the old exam format) or a ratio score not lower than 0.92 (given that previously ~60% of the questions were answered correctly, thus CU 0.55 / natl 0.60 = 0.92). Although in three cases individual topics failed to meet our goal, averaged across the five subject areas we never failed to meet our goal in one of the assessment cycles. In three academic years, CU student performance exceeded national peers. Overall, no weakness in this outcome is evident.

FE Topic	YEAR	11-12	12-13	F13	Sp14	14-15	15-16	F16
	# CU students	*98*	*92*	*56*	*16*	*36*	*52*	*14*
Hydraulics/	Ratio				1.05	.97	1.03	.94
Hydrology	*% vs. Natl*	*2*	*5*	*7*				
Geotech	Ratio				1.10	.95	1.02	1.02
Soil/Found	*% vs. Natl*	*2*	*5*	*0*				
Environ	Ratio				1.09	.92	1.02	.98
engineering	*% vs. Natl*	*2*	*0*	*-3*				
Structural	Ratio				.99	.96	.95	.93
analysis	*% vs. Natl*	*-4*	*-7*	*0*				
Construction	Ratio				1.09	.89	.99	1.09
management	*% vs. Natl*	*-6*	*2*	*6*				
5-topic avg	Ratio	*-1*	*1*	*2*	*1.06*	*.94*	*1.00*	*.99*
	% vs. Natl							

Outcome 6 [e] Student Ratings on Course FCQs

The ability to solve engineering problems was one of the highest rated outcomes by the students of the required courses in the curriculum overall, with an average rating of 4.7 across all the courses in the curriculum. Thus, practically any course could be used to assess this outcome. Data from two engineering science courses (fluids and dynamics) and one CVEN fundamental course were selected for illustrative purposes, shown below. These data show that our goal of three or more courses rated at 4 or higher was met each year.

Problem Solving Outcome: Student Ratings on Required Course FCQs (0-6 scale)

Academic Year	CVEN 3313 Fluids	CVEN 3414 Fund. Environmental Engrg	CVEN 3111 Dynamics
2011-12	5.5	4.0, 4.6	5.5
2012-13	4.7	4.5, 5.0	5.2
2013-14	5.4	4.3, 4.6	5.3
2014-15	4.3	4.5, 5.0	4.3
2015-16	5.7	4.7, 5.2	4.7
2016-17	5.2	5.1, 5.6	4.6

Outcome 6 [e] Senior Survey

The ability to identify, formulate, and solve engineering problems was rated at a sufficient level of average achievement by CVEN students, with ratings at or above 4.0. No weakness is evident from these data.

Senior Survey (avg ratings 1-5 scale)	Year	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*55*	*77*	*84*	*59*	*60*
ID, formulate, solve eng problems		4.0	4.3	4.2	4.4	4.3

Summary: The direct assessment data from the FE exam, strong student ratings in many required undergraduate civil engineering courses, and self-ratings by students on the senior survey all support that CU CVEN students have adequate ability to identify, formulate, and solve engineering problems when they graduate.

Outcome 7 [f]. Professional and Ethical Responsibility

Outcome 7 [f] FE Exam

There are questions on the FE exam that relate to professional and ethical responsibility, which we use as a direct assessment for ABET. During the 2013-2014 academic year, CU students failed to meet our performance goal for this outcome (on the new format of the exam in the spring). The following year in 2014-2015, performance was acceptable (above 0.92) but of concern, due to just barely exceeding our minimum. In response to dissatisfaction with student performance on the ethics and professional practice questions on the FE exam, we increased curricular content related to this topic, primarily in the new required Professional Issues course. The new course was taught for the first time in fall 2015. The focus on Ethics also increased in the required CVEN 3246 Introduction to Construction Management course that is typically taken in the junior year. Performance improved in 2015-16, and in fall 2016 was well above other CVEN programs nationally. Overall, we consider that we met our goal, but will continue to monitor student knowledge of professional and ethical issues.

FE Topic	Year	11-12	12-13	F13	Sp14	14-15	15-16	F16
	n CU students	*98*	*92*	*56*	*16*	*36*	*52*	*14*
Profession & ethics	Ratio score				.90	.93	.97	1.14
	% Difference	*-2*	*0*	*-4*				

Outcome 7 [f] Senior Design Quiz

The capstone senior design course includes a lecture about professional ethics and evaluates student knowledge of this topic via two to three questions as part of a larger individual quiz (that also included questions on topics such as lifelong learning, contemporary issues, impact of engineering on society, and leadership). However, student performance on the questions related to the different topics were not recorded separately from the overall performance in 2013-2016, so assessment data is not available except in spring 2017. The spring 2017 data shows that met our goal that 80% of the students scored at an adequate or higher level (adequate 80-90%). However, the few questions and grading style (right, half credit, or wrong) means that this assessment method has a limited ability to give a quality assessment of student knowledge. Given the limited utility of this assessment method and richer data available from the FE exam and Professional Issues course, use of quiz performance in senior design to assess students' knowledge of ethics will be discontinued.

Capstone Design Course		Percentage of Students at Each Performance Level			
Quiz Topic	Year	Poor	Needs Improvement	Adequate	Superior
Ethics (3 questions)	Sp2017	10	0	0	90

Outcome 7 [f] Direct Assessment: Student Performance on Quiz/Homework

In the Professional Issues course, one assignment relates specifically to ethics. Performance on this assignment is used as an embedded indicator of the level of student knowledge on ethics. For the technical elements graded on the assignment (excluding writing, format, and references), the following percentages were converted into the rubric scores below: >90% superior, 80-90%

adequate, 70-80% needs improvement, <70% poor. The goal is for 80% or more of the students to perform at an adequate or higher level. This goal was met in 2015 and 2016.

Prof Issues Course			Percentage of Students at Each Performance Level			
Homework	Year	n	Poor	Needs Improvement	Adequate	Superior
Ethics	F2015	19	5	5	21	68
	F2016	56	5	2	9	84

In the Introduction to Civil Engineering course, one assignment related specifically to ethics and professional licensure. Using the same mapping of student performance to acceptable levels as was used in the Professional Issues course, students' knowledge of ethics is summarized below. Each year, over 80% of the students evidenced adequate knowledge of ethics, which meets our goal.

Introduction to Civil Engineering Course			Percentage of Students at Each Performance Level			
Homework Topic	Year	n	Poor	Needs Improvement	Adequate	Superior
Ethics	F2011	48	4	8	10	77
	F2012	45	4	2	4	89
	F2013	65	11	2	2	86
	F2014	54	6	4	7	83
	F2015	52	10	4	10	77
	F2016	39	10	8	8	74

Outcome 7 [f] JEC Review

The 2014 geotechnical JEC felt that an understanding of professional and ethical responsibility was lacking in the curriculum. That JEC review pre-dated the addition of CVEN 4897 Professional Issues in Civil Engineering to the curriculum requirements; the new course was offered for the first time in fall 2015. The Professional Issues course has a strong emphasis on the path to professional licensure, the importance of professional licensure, and ethics. We believe this addresses the concern noted by the JEC.

Outcome 7 [f] Student Ratings on Course FCQs

The understanding of ethics and professional responsibility is a focus in a small number of courses. Ethics is focused in three locations in the curriculum: beginning in the first semester Introduction to Civil Engineering course, middle in the Introduction to Construction course (for most students, fall of junior year), and the end in Senior Design or more recently the Professional Issues course. The Professional Issues course in fall 2017 failed to meet our targeted student assessment rating of 4.0 or higher; the course overall has not been popular with students, although direct evidence from the homework assignment and multiple-choice questions to practice for the FE exam show adequate student knowledge. In each year, three courses were rated at 4 or higher in each academic year, thus our goal for this outcome was met.

Professional and Ethical Responsibility: Student Ratings on Required Course FCQs

Academic Year	CVEN 1317 Intro CivilE	CVEN 3246 Intro Construction	CVEN 4899 Senior Design	CVEN 4897 Prof Issues
2011-12	5.2	4.9, 5.3	4.8	N/A
2012-13	4.7	5.0, 4.6	5.2	N/A
2013-14	5.1	5.1, 4.6	5.0	N/A
2014-15	5.2	5.4, 4.6	4.8	N/A
2015-16	5.4	5.3, 5.2	4.1,4.9	4.6
2016-17	4.9	5.3, 4.9	4.9	3.9

N/A = course not offered in those years

Outcome 7 [f] Senior Survey

Two survey items were used to evaluate this outcome: an understanding of professional responsibilities of an engineer and understanding of the ethical issues confronting an engineer. Both were rated at a sufficient level of average achievement by CVEN students. No weakness is evident from these data.

Senior Survey (avg ratings 1-5 scale)	Year:	2011-12	2012-13	2013-14	2014-15	2015-16
# responses		*56*	*75,77*	*85*	*59*	*60*
Professional responsibilities		3.7	4.0	4.2	4.0	4.0
Ethical issues		3.5	3.9	4.0	3.9	4.0

<u>Summary:</u> With a single exception in one semester of FE data, both the direct and indirect data are uniformly supportive that civil engineering students from our program have sufficient knowledge of ethical and professional issues.

Outcome 8 [g]. Effective Communication through Writing and/or Drawings

Outcome 8 [g] Senior Design Rubric

In the senior design course, the final team concept design reports were graded using a rubric, with three elements to embody written communication ability. Each semester four graders rate each team using a scale of 1 to 4 (some gave decimal ratings, corresponding to: 2-2.9 needs improvement, 3-3.5 adequate, 3.6-4 superior). Over 80% of the teams were adequate or higher in all four categories, indicating adequate oral presentation skills among the CVEN students.

Term	Oral Presentation Elements	Poor 1	Needs Improvement 2	Adequate 3	Superior 4
		Percentage of Ratings at Each Level of the Rubric			
F2013	Style	0	0	24	76
	Organization	0	1	24	75
	Communicate via drawings	0	0	29	71
F2014	Style	0	0	30	70
	Organization	0	3	40	57
	Communicate via drawings	0	3	35	62
F2015	Style	0	0	31	69
	Organization	0	0	22	78
	Communicate via drawings	0	0	22	78
Sp2016	Style	0	9	50	41
	Organization	3	0	50	47
	Communicate via drawings	0	3	28	69
Sp2017	Style	0	0	23	77
	Organization	0	0	20	80
	Communicate via drawings	0	2	34	64

** Fall 2012 data on written communication element not reported from instructor*

Outcome 8 [g] JEC Review

Some of the JECs have commented on written communication abilities. The 2014 Construction Engineering & Management (CEM) JEC recommended placing a greater emphasis on technical writing; faculty noted that "CVEN 3246 involves a project where 30% of the score is writing, and the students also receive direct one-on-one feedback from the instructor on their draft reports." The 2015 environmental & water resources JEC also noted that there should be a strong emphasis on communication skills in the CVEN curriculum. This included concerns with the current required writing course, as well as a recommendation to infuse writing requirements in core courses. A number of faculty are increasing their emphasis on writing (Prof. Neupauer in CVEN 3323 Hydraulics, Prof. Montoya in AREN 2110 Thermodynamics), in addition to efforts at the College level to review writing. With respect to drawing, the 2016 structures JEC made a general comment that building information modeling (BIM) should continue to be an integral part of the drawing course.

Outcome 8 [g] Student Ratings on Course FCQs

The ability to communicate effectively via writing and drawing were separately rated items by the students, and different courses emphasize these outcomes. Written communication is the focus of an entire required junior-level writing course; but it is offered outside the department and CVEN students are spread across numerous sections. Written communication is a strong focus in the senior capstone design course (as described above), and is also somewhat of a focus in the Introduction to Civil Engineering course, Introduction to Construction, and courses that require laboratory write-ups such as CVEN 3161. However, the extent to which instructors focus on quality writing as part of the labs varies, as shown below for CVEN 3161. In 2013-2014 we failed to meet our goal of three or more required courses with average ratings by students of 4 or higher in 2 of the 6 academic years. Recently, faculty are trying to infuse writing into other courses (such as Neupauer into CVEN 3323 Hydraulics).

Communicate in writing: Student Ratings on Required Course FCQs (0-6 scale)

Academic Year	CVEN1317 Intro CivE	CVEN3246 Intro Constr	CVEN3161 Mech Matls	CVEN3323 Hydraulics	CVEN3708 Geotech1	CVEN4899 Sr Design
2011-12	4.2	4.1, 4.1	2.8, 3.5	3.7	4.1, 2.9	5.1
2012-13	4.2	4.1, 4.2	2.8, 4.2	3.5	4.0, 3.5	5.3
2013-14	3.9	3.8, 4.2	3.4, 4.7	3.7	4.2, 3.5	5.1
2014-15	4.4	3.4, 3.8	2.6, 4.1	3.9	3.0, 3.1	5.0
2015-16	4.6	4.2, 4.4	4.3, 4.4	3.7	2.6, 4.6	4.6, 5.1
2016-17	4.0	3.8, 4.4	3.5, 3.0	4.4	3.4, 2.7	5.4

In the old curriculum, students took a full 3-credit course on engineering drawing. More recently, drawing was combined with Geomatics – but the instructors failed to administer FCQs separately to those students. Starting in Fall 2017, students will be required to take a full 3-credit drawing course. Regardless, in each year at least three courses had a rating of 4 or higher, indicating no deficiency in this area.

Communicate via drawings outcome: Student Ratings on Required Course FCQs (0-6 scale)

Academic Year	AREN 1027 Drawing	CVEN 2012 Geomatics	CVEN 3246 Intro Construction	CVEN 4899 Senior Design
2011-12	5.3	4.2	4.2, 4.1	5.2
2012-13	4.7	4.2	4.4, 4.4	5.5
2013-14	4.6	2.8	4.6, 4.0	5.2
2014-15	5.0	3.3	4.6, 4.1	4.7
2015-16	5.0	4.4	4.9, 5.1	4.8, 5.2
2016-17	5.2, 4.5	2.9	5.0, 4.7	4.9

Outcome 8 [g] Senior Survey

The ability to communicate effectively in writing (reports, etc.) and to use drawings were rated at a sufficient level of average achievement by CVEN students, with marginal performance in two evaluation cycles for writing and 4 evaluation cycles for drawings. Based on these data, we satisfied our minimum goal (all ratings 3.5 or higher).

Senior Survey (avg ratings, 1-5 scale)	Year:	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*56*	*77*	*85*	*59,58*	*60*
Communicate in writing		3.5	3.8	3.8	3.7	3.8
Communicate using drawings		3.6	3.6	3.8	3.5	3.6

Summary: While the indirect assessment provided marginal data of sufficiently fulfilling the communication through writings and drawings outcome, the direct evidence in senior design leads us to conclude sufficient fulfillment of this outcome. However, efforts will continue to improve students' writing abilities and the revised curriculum going into effect in Fall 2017 will up the requirement from 1 credit of drawing to 3 credits.

Outcome 9 [g]. Effective Communication through Oral Presentations

Outcome 9 [g] Senior Design Rubric

In the senior design course, the final team oral presentations were graded using a rubric, with four elements to embody oral presentation ability. Each semester four graders rate each team using a scale of 1 to 4 (some make use of decimal ratings, corresponding to: 3-3.5 adequate, 3.6-4 superior). (In 2012, a rubric was used, but only the overall scores across the elements were recorded for outcomes assessment.) Over 80% of the teams were adequate or higher in all four categories, indicating adequate oral presentation skills among the CVEN students.

Term	Oral Presentation Element	Poor 1	Needs Improvement 2	Adequate 3	Superior 4
		Percentage of Ratings at Each Level of the Rubric			
F2012	Overall	0	0	27	73
F2013	Quality of content	0	2	23	75
	Presentation Mechanics	0	0	30	70
	Visual Aids	0	0	23	77
	Questions	0	0	20	80
F2014	Quality of content	0	0	33	67
	Presentation Mechanics	0	0	25	75
	Visual Aids	0	3	30	67
	Questions	0	0	25	75
F2015	Quality of content	0	0	31	69
	Presentation Mechanics	0	0	31	69
	Visual Aids	0	0	16	84
	Questions	0	0	31	69
Sp2016	Quality of content	0	0	31	69
	Presentation Mechanics	0	0	25	75
	Visual Aids	0	0	25	75
	Questions	0	0	41	59
Sp2017	Quality of content	0	0	27	73
	Presentation Mechanics	0	0	5	95
	Visual Aids	0	2	20	77
	Questions	0	0	11	89

Outcome 9 [g] JEC Review

Some of the JECs have commented on oral communication abilities. The 2014 Construction Engineering & Management (CEM) JEC recommended improving the oral and presentation skills of the students. The CEM faculty responded: "greater emphasis on oral presentation has recently been introduced throughout the CEM curriculum. …students do give presentations on their bridge projects in CVEN 3246." In addition, student FCQ data is a strong indicator that oral presentations have been added into a proficiency course, CVEN 3256 Construction Equipment and Methods; starting in spring 2014, ratings related to improved their ability to make effective oral presentations has been 4.6 and higher (on 6.0 scale) compared to ratings from fall 2010 – fall 2013 of 1.3-3.6.

The 2014 Geotechnical Engineering JEC also noted a concern with oral presentation; they noted that students should be required to participate in an oral presentation course during their undergraduate program. A course on oral communication is not required. However, students can take such a course if desired as a free elective. Furthermore, all students participate in multiple oral presentations as part of their capstone design course and, as noted above, oral presentations were also added into CVEN 3246. We therefore believe that we addressed the spirit of the JEC concern, despite not adding a new course requirement into the curriculum.

Outcome 9 [g] Student Ratings on Course FCQs

The ability to communicate effectively via oral presentations is only included within a few courses in the curriculum. The largest and most consistent emphasis is in the senior design course. Oral presentation has had variable focus in other courses: e.g., it is sometimes strong but also sometimes not present in Engineering Geology; it historically has a higher chance of being present in Introduction to Construction, but can go semesters without a strong focus in, e.g., Fundamentals of Environmental Engineering. For two years, there were not three required courses rated as 4.0 or higher by the students for oral presentations. Thus, the oral presentations outcome did not reliably meet our indirect evidence criteria for student FCQs.

Communicate via oral presentations: Student Ratings on Required Course FCQs

Academic Year	CVEN 1317 Intro CivilE	AREN 1027 Drawing	CVEN 3246 Intro Constr	CVEN 3698 Eng Geol	CVEN 3414 Fund EnvE	CVEN 4899 Design
2011-12	3.8	1.6	3.0, 4.0	4.7	4.3, 3.9	5.1
2012-13	3.4	3.7	3.7, 4.2	1.7	3.6, 3.9	5.4
2013-14	3.9	3.7	3.0, 3.5	1.0	3.4, 1.3	5.3
2014-15	4.1	4.7	2.7, 2.5	4.0	4.5, 4.9	5.0
2015-16	3.9	4.5	3.2, 2.8	4.5	1.0, 1.6	4.8, 5.3
2016-17	2.6	5.0, 3.8	2.8, 2.9	4.5	1.6, 1.9	5.3

Outcome 9 (g) Senior Survey

The ability to communicate effectively via oral presentations showed improvement from 2011/12 to 2014/15; the more recent data shows a sufficient but somewhat marginal level of achievement by CVEN students.

Senior Survey Avg rating 1-5 scale	Year:	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*55*	*77*	*84*	*59*	*60*
Oral communication		3.4	3.5	3.8	3.8	3.7

Summary: The strongest measure that students have sufficient ability to make oral presentations is based on direct evaluation on multiple measures by the four co-instructors of the senior design course. The students make multiple formal oral presentations in the course, and the final presentation has provided strong evidence of good oral presentation abilities by the majority of the students. Thus, strong focus in that single course outweighs the fact that a large number of the courses do not emphasize oral communication. The direct assessment measurement supports sufficient attainment of this outcome.

Outcome 10 [h]. Understand the impact of engineering on society

Outcome 10 [h] Direct Assessment: Course Assignments

Sustainability considers societal, economic, and environmental issues. As such, students demonstrating an ability to assess the sustainability attributes of engineering projects also demonstrate an understanding of the impact of engineering solutions in a societal, economic, and environmental context. Therefore, one direct assessment method used for this outcome was an embedded indicator within the sustainability homework assignment in the Professional Issues course. The homework assignment on sustainability included a question related to societal impacts, where students were required to discuss how the planning and/or rebuilding activities in New Orleans after Hurricane Katrina could earn credits under the ENVISION 2.0 rating ratings under the Quality of Life category. ENVISION is a sustainable infrastructure rating system developed by ISI. The Quality of Life category includes credits for elements such as: improve community quality of life, stimulate sustainable growth and development, develop local skills and capabilities, enhance public health and safety, minimize noise and vibration improve community mobility and access, preserve historic and cultural resources, enhance public space, etc. The student performance on the rubric is shown below. In 2015, there was adequate knowledge of societal issues demonstrated (more than 80% of the students scored at an adequate or better level, by earning 80% or more of the points on the question). In 2016 student performance did not meet our goal. A key difference across the two years was the interpretation of the rubric in 2015 from the course instructor and in 2016 by a PhD-level grader. If the "adequate" bar was changed to above 70% for 2016 (which is a C, and generally considered adequate), 91% of the students met this criteria. Future consideration will determine if the instructor should always grade the embedded indicator question to ensure greater consistency.

Prof Issues Course			Percentage of Students at Each Performance Level			
Homework	Year	n	Poor	Needs Improvement	Adequate	Superior
Sustainability:	F2015	19	0	5	5	90
Quality of Life	F2016	56	9	32	41	18

In the Introduction to Civil Engineering course, much of the content focused on the impact of engineering in a global, economic, environmental, and societal context. For example, the second homework encompassed sustainability (social, environmental, and economic). Using student performance on this assignment as an embedded indicator, students routinely demonstrated adequate knowledge of this outcome, with over 80% at the adequate or higher level.

Intro CivilE Course			Percentage of Students at Each Performance Level			
Homework	Year	n	Poor	Needs Improvement	Adequate	Superior
Environmental, economic, social impacts	F2011	48	4	0	15	81
	F2012	45	7	4	11	78
	F2013	65	2	2	3	94
	F2014	54	4	2	15	80
	F2015	52	6	4	19	71
	F2016	38	11	8	16	66

Outcome 10 [h] Student Ratings on Course FCQs

The impact of engineering on society was routinely rated by CVEN students as a strong outcome for three required courses, at the beginning, middle, and end of the curriculum. These courses all had minimum ratings of 4.7 and higher, well above the minimum target of 4.0. Thus, no weaknesses were identified for this outcome.

Impacts on Society: Student Ratings on Required Course FCQs (0-6)

Academic Year	CVEN 1317 Intro CivilE	CVEN 3414 Fund EnvE	CVEN 4899 Design
2011-12	5.1	5.1, 4.9	4.8
2012-13	4.7	5.4, 5.5	5.3
2013-14	5.2	4.7, 5.1	5.1
2014-15	5.2	5.1, 5.4	5.0
2015-16	5.4	5.5, 5.7	4.8, 5.1
2016-17	4.8	5.5, 5.7	4.6

Outcome 10 [h] Senior Survey

The impacts of engineering solutions in a global, economic, environmental, and social context was rated at a sufficient level of average achievement by CVEN students, with ratings at or above 3.8 (on a 1-5 scale, with target over 3.5). No weakness is evident from these data.

Senior Survey Avg rating 1-5 scale	Year	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*55*	*77*	*84*	*59*	*60*
Societal context		3.8	4.0	4.2	4.2	3.9

Summary: Both indirect measures were consistently strong in students' self-reported understanding of the impact of engineering in a global, economic, environmental, and social context. The direct measure in the first-year introductory course was also consistently strong. The indicator selected in the senior Professional Issues course showed a weakness in 2016, but was sufficient in 2015. The homework question used to assess the outcome changed somewhat between 2015 and 2016. Given the newness of the course and assessment, future modifications to the embedded indicator for societal context in the course may occur as we seek a good metric. But overall, the assessment data is supportive that our students are meeting this outcome.

Outcome 11 [i]. Necessity to Engage in Life-Long Learning (LLL)

Outcome 11 [i] FE Exam

We believe that students' overall performance on the FE exam is indicative of their motivation, ability, and willingness to engage in lifelong learning, given that this is a first step on the path to become a licensed PE, and PE licensure requires additional learning. CU CVEN students did well on the old FE 8-hour exam format, generally exceeding peer CVEN students nationally. However, our student performance has been weak since the switch to the new format. This has been of significant concern to both faculty and our JECs. Starting in fall 2016 all students were required to take an online practice exam to simulate the new FE, as part of the required CVEN 4897 Professional Issues in Civil Engineering course. However, many of those students are taking the exam in spring 2017 and we will not have access to their performance data until July 2017. This data will be provided at the time of the site visit or can be provided sooner, at the request of the team chair. The students' performance on the FE exam in terms of overall passing rate is a concern.

Year	11-12	12-13	F13	Sp14	14-15	15-16	F16
n CU students	*98*	*92*	*56*	*16*	*36*	*52*	*14*
New exam % difference				-5	-15	0	-10
Old exam % Difference	*0*	*8*	*13*				

Outcome 11 [i] Senior Design Quiz

The capstone senior design course includes a lecture about lifelong learning and evaluates student knowledge of this topic via one to three questions as part of a larger individual quiz. However, student performance on the questions related to the different topics were not recorded separately from the overall performance in 2013-2016, so assessment data is not available except in spring 2017. The spring 2017 data shows that we met our goal that 80% of the students scored at an adequate or higher level (adequate 80-90%). The single question and grading style (right, half credit, or wrong) means that this assessment method has a limited ability to give a quality assessment of student knowledge. Given the limited utility of this assessment method, it will likely be discontinued.

Capstone Design Course		Percentage of Students at Each Performance Level			
Quiz Topic	Year	Poor	Needs Improvement	Adequate	Superior
Lifelong learning (1 question)	Sp2017	11	0	0	89

Outcome 11 [i] Direct Assessment: Course Assignments

In the Professional Issues course the homework assignment on the ASCE Body of Knowledge relates to lifelong learning, as it requires students to consider the additional knowledge and skills that they need to develop prior to professional licensure, via additional education (such as a Master's degree) and/or on the job. Student scores on the question fell into categories as shown below. More than 80% of the students demonstrated adequate or better knowledge, meeting our benchmark for adequacy.

Prof Issues Course			Percentage of Students at Each Performance Level			
Homework	Year	n	Poor	Needs Improvement	Adequate	Superior
Body of Knowledge	F2015	19	5	5	11	79
	F2016	56	5	5	11	79

The Introduction to Civil Engineering course included homework questions on the ASCE Body of Knowledge on Homework 1, but the graders sometimes failed to log performance on this question distinct from the overall grade before returning assignments to students (2014 and 2016). In addition, Fall 2013 data is missing due to a non-standard instructor who is now retired and did not separately report this information. In two of the three years with data available, student knowledge of the BOK was sufficient; over 80% scored adequate or higher. In 2015, 28% of the students failed to meet the target level of proficiency. The Introduction to Civil Engineering course also included homework questions on the path to professional licensure and why licensure is important (in early years as part of homework 1, later added to homework 4; again, 2013 data is missing due to the non-standard instructor not separately logging student performance on this question). In 3 of the 5 years with data available, student performance was sufficient, including 2015 when the students were below the target for BOK as an indicator of lifelong learning. The large differences in performance between years may also be somewhat of a function of the strictness of the graders (which varied year to year and was particularly stringent in 2016), in addition to variability in student knowledge. It is hoped that the 2016 cohort of first-year students will demonstrate improved understanding of the path to professional licensure in their senior year during the Professional Issues course.

FY Intro Course			Percentage of Students at Each Performance Level			
Homework	Year	n	Poor	Needs Improvement	Adequate	Superior
Body of Knowledge	F2011	47	0	0	0	100
	F2012	44	2	2	14	82
	F2015	50	14	14	2	70
Professional Licensure	F2011	47	2	4	2	92
	F2012	44	9	14	16	61
	F2014	52	2	4	8	87
	F2015	49	8	0	51	41
	F2016	39	21	13	33	33

Outcome 11 [i] Joint Evaluation Committees (JECs)

The structures JEC has cited concerns about FE pass rates and students understanding of why professional licensure is important. This mirrors our own concerns with FE pass rates, and our stepped-up emphasis on professional licensure through the Professional Issues course. It is too soon to tell if the new course is making a difference. The Fall 2015 pilot was only taken by 19 students, largely those who transferred to civil engineering (about a third of the graduating class). The Fall 2016 course was taken by the majority of fourth-year students, but some were not planning to graduate until 4.5 or 5 years, so would not yet have taken the FE exam.

JEC	Year	Comment
Structures	2016	Students do not exhibit a good understanding of what it is required to become licensed as a professional engineer, what coursework potential employers require, and the importance of registration as an engineer-intern.
Structures	2013	FE pass rates exhibit alarming decline in recent years. They recommend teaching 3 times in ugrad curriculum – first year (this is being done and part of HW assignment), required junior year course and sample exam (not being done, although CVEN3414 includes FE-type questions on some assignments), and included in required senior year course (this is being done in the Professional Issues course, with reviews and two practice exams)

Outcome 11 [i] Student Ratings on Course FCQs

The need for and ability to engage in lifelong learning were both rated as potential course outcomes. About half of the required courses had student ratings of 4 or higher for this outcome. Four courses are used to illustrate the fact that we met our target for student ratings of this outcome (see below).

Need for/ability to engage in lifelong learning: Student Ratings on Required Courses (0-6)

Academic Year	CVEN 1317 Intro CivilE	CVEN 3323 Hydraulics	CVEN 3414 Fund EnvE	CVEN 4899 Design
2011-12	4.7/4.5	4.5/4.5	4.0/3.9; 4.4/4.4	4.7/4.6
2012-13	4.4/4.1	4.5/4.3	4.8/4.5; 4.7/4.6	5.1/4.9
2013-14	4.5/4.3	4.7/4.7	4.1/4.2; 4.6/4.4	5.1/5.0
2014-15	4.6/4.3	5.0/5.0	4.6/4.4; 4.7/4.8	4.8/4.8
2015-16	5.0/4.7	4.5/4.5	4.5/4.3; 5.3/5.2	4.6/4.7, 5.1/5.0
2016-17	4.6/4.4	5.1/5.1	5.1/4.9, 5.5/5.5	5.1/5.0

Outcome 11 [i] Senior Survey

Two survey items were used to evaluate this outcome: motivation, ability, and willingness to engage in lifelong learning, and ability to use the Internet, library, or other sources to research an issue. The second item relates to the ability to engage in lifelong learning on one's own. Both were rated at a sufficient level of average achievement by CVEN students. No weakness is evident from these data.

Senior Survey Avg rating 1-5 scale	Year	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*56*	*77,76*	*85*	*59*	*60*
Lifelong learning		3.6	4.0	3.9	3.9	3.9
Research an issue		3.7	4.3	4.4	4.2	4.2

<u>Summary</u>: Across the multiple measures of lifelong learning, including a variety of both direct and indirect indicators, some measures failed to meet our target in some years. The indirect assessment data was consistently strong while the multiple direct measures were variable. We believe that students have an awareness of the importance of LLL and an ability to engage in

LLL. However, many simply do not have professional licensure in their future plans. At present, efforts are underway to explore ways to bolster the commitment of the students to lifelong learning as evidenced by commitment to pursue professional licensure.

Outcome 12 [j]. Contemporary Issues

Outcome 12 [j] FE Exam

There are questions on the FE exam that measure students' knowledge of engineering economics topics. We believe that economic issues are contemporary issues relevant to civil engineering, and thus consider this a direct assessment related to this outcome. Historically, CU students performed better than national peers on engineering economics questions. Recent performance in two academic years was below national peers but still deemed acceptable. Thus, we do not have evidence of a student deficiency related to this outcome based on the FE data.

FE Topic	Year	11-12	12-13	F13	Sp14	14-15	15-16	F16
	n CU students	*98*	*92*	*56*	*16*	*36*	*52*	*14*
Engineering Economics	Ratio score				1.12	.95	.97	1.09
	% Difference	*1*	*3*	*5*				

Outcome 12 [j] Direct Assessment: Course Assignments

In the Professional Issues course the homework assignment on sustainability relates to current events and contemporary issues, as it required students to learn about a key issue for civil engineering practice in the context of continuing efforts to rebuild New Orleans after Hurricane Katrina. Student scores on the assignment fell into categories as shown below. More than 80% of the students demonstrated adequate or better knowledge in 2015, meeting our benchmark for adequacy. However, in 2016 the scores were much lower. One reason for the difference may be that the 2015 assignments were graded by the instructor and the 2016 assignments were graded by a PhD-level TA (a much more rigorous grader). In 2016 over 80% of the students scored 70% or better (a C-, which is generally considered adequate). In the future, the instructor may need to grade this assignment that serves as an ABET embedded indicator to increase consistency.

Prof Issues Course			Percentage of Students at Each Performance Level			
Homework	Year	n	Poor	Needs Improvement	Adequate	Superior
Sustainability	F2015	19	0	5	11	84
	F2016	56	13	16	38	34

Prior to the incorporation of the Professional Issues course in the curriculum, contemporary issues were also incorporated into the capstone senior design course with students' knowledge assessed with 3 questions on a quiz; however, student performance on these questions was not tracked separately among the 20 questions on the quiz overall.

The first assignment in the Introduction to Civil Engineering course focuses on contemporary issues, including needs for infrastructure. In 2014-2016, the first question asked students to describe a contemporary challenge in civil engineering that inspires their career goals; the problem is worth 15 points. Similarly, in 2011 to 2013, question 3c on the first assignment had students describe a current project that they found in the news that would involve a civil engineer. If students received >90% of the points their performance was deemed superior, 80-90% adequate, 70-80% needs improvement, and <70% poor. Student performance demonstrated an acceptable level of knowledge of contemporary issues in 2012-2016, with over 80% of the students rated as adequate or higher; in 2011 performance fell short of that goal with only 77%

of the students at adequate or higher. However, given that this course occurred in the first year of the curriculum, there was additional opportunity for the Fall 2011 students to learn about contemporary issues in subsequent courses.

Intro CVEN Course			Percentage of Students at Each Performance Level			
Homework 1	Year	n	Poor	Needs Improvement	Adequate	Superior
Q1/3c. Contemporary issue	F2011	47	9	15	2	75
	F2012	45	4	0	4	91
	F2013+	67	3	0	3	94
	F2014	54	7	0	19	74
	F2015	52	13	0	19	67
	F2016+	38	0	5	26	68

+ In 2013, the normal professor for this course was on sabbatical; the instructor that year did not log student performance on question 3c distinct from the rest of homework 1. In 2016, the TA did not log student performance on homework 1 questions separately, so these scores include contemporary issues and BOK2 topics (which some may also perceive as a contemporary issue)

Outcome 12 [j] JEC Review

The 2014 geotechnical JEC felt that knowledge of contemporary issues was lacking in the curriculum. That JEC review pre-dated the addition of CVEN 4897 Professional Issues in Civil Engineering to the curriculum requirements; the new course was offered for the first time in Fall 2015. The Professional Issues course has an emphasis on contemporary issues including sustainability (teaching students about the ENVISION rating system), resilience, the Body of Knowledge, attempts to "raise the bar" to require a Master's degree for professional licensure, etc. We believe this addresses the concern noted by the JEC.

Outcome 12 [j] Student Ratings on Course FCQs

An understanding of current events and contemporary issues was consistently achieved in three or four required courses, based on student ratings of the courses (see below); this meets our minimum criteria.

Current Events and Contemporary Issues: Student Ratings on Required Course FCQs (0-6)

Academic Year	CVEN 1317 Intro CivilE	CVEN 3414 Fund EnvE	CVEN 3246 Intro Construction	CVEN 4899 Senior Design
2011-12	4.6	5.1, 5.0	4.4, 4.8	4.1
2012-13	4.4	4.9, 5.1	4.9, 4.6	4.6
2013-14	4.2	4.4, 5.0	5.0, 4.6	4.6
2014-15	4.7	4.8, 4.8	4.9, 3.9	4.9
2015-16	4.9	4.9, 5.0	5.2, 5.4	4.2,4.6
2016-17	4.0	5.2, 5.3	5.6, 4.1	4.1

Outcome 12 [j] Senior Survey

Three questions relate to outcome 12: an understanding of current events and contemporary issues; apply the principles of sustainability to design; and global context. The second two items are considered important contemporary issues relevant to civil engineering and provide students with specific examples of these issues. In two assessment cycles the college inadvertently left the contemporary issues question off the senior survey. Where data is available, the students were more positive in rating the specific examples of contemporary issues. The overall average across the multiple assessment items was 3.4, which is below our minimum sufficiency level of 3.5. The data indicate that this outcome is of concern, with marginal fulfillment in recent years.

Senior Survey Avg rating 1-5 scale	Year	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
# responses		*55*	*77*	*84*	*59*	*58-60*
Current events		3.1	N/A	N/A	3.4	3.5
Sustainability		3.2	3.5	3.6	3.5	3.6
Global context		3.3	3.4	3.6	3.5	3.7

Summary: This outcome appears to have the weakest supporting data. Direct assessment data from the FE exam showed that CU students have adequate knowledge of engineering economics. Direct assessment data from the first-year introduction to civil engineering course found that students have adequate knowledge of contemporary issues in 2012-2016, based on performance on a related homework assignment. Only two years of data is available for the new senior-level professional issues course; results were mixed on knowledge of sustainability, as a representative contemporary issue. Among the indirect assessment data, an adequate number of courses met our target of being assessed by students at 4.0 or higher, while the graduating senior survey data was marginal or failed to meet our goal. However, students who have taken the professional issues course will not comprise the bulk of the students completing the senior survey until May 2016; that data is not available for the current self-study. We will be monitoring this outcome carefully, largely via the professional issues course.

Outcome 13 [k]. Modern engineering techniques, skills, and tools

Outcome 13 [k] FE Exam

CU CVEN student performance on the computers / computational tools questions on the FE exam have been consistently very strong, exceeding national peers in four assessment cycles. This is strong direct evidence of achievement of this outcome.

FE Data	Year	11-12	12-13	F13	Sp14	14-15	15-16	F16
	n CU students	*98*	*92*	*56*	*16*	*36*	*52*	*14*
Comp Tools	Ratio score				1.04	1.00	1.02	1.00
Computers	*% Difference*	*5*	*7*	*8*				

Outcome 13 [k] Senior Design Rubric

In the senior design course, students must use AutoCAD or Revit to create drawings to communicate their designs. This element of the students' final report is graded and provides evidence of whether students have adequate knowledge of appropriate tools.

Ability to effectively use CAD/Revit	Poor 1	Needs Improvement 2	Adequate 3	Superior 3
Term	Percentage of Ratings at Each Level of the Rubric			
F2013	0	0	29	71
F2014	0	3	35	62
F2015	0	0	22	78
Sp2016	0	3	28	69
Sp2017	0	2	34	64

Outcome 13 [k] JEC Review

The 2014 Construction Engineering & Management (CEM) JEC was concerned about diminished CAD/Drawing content in the curriculum and stated that "CEM students need to be comfortable using modern CAD modeling programs." The faculty indicated that an assignment requiring the use of CAD would be introduced into CVEN 3256 Construction Equipment and Methods. That course is the proficiency course for CEM; therefore, not all CVEN students take the course, but those interested in CEM certainly enroll.

The 2014 Geotechnical Engineering JEC was also concerned about a lack of representations of "an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice." Their concerns were more specific to geotechnical engineering including visual classification of soils and site investigation. The geotechnical engineering faculty have added the requested elements into the CVEN 3708 Geotechnical Engineering I course that is required for all students, and site investigation is included in the CVEN 3698 Engineering Geology course that is an optional basic science course for civil engineering students. In addition, it is noted that computer-based models for seepage and slope stability problems are routinely included in homework assignments for the students.

Outcome 13 [k] Student Ratings on Course FCQs

An ability to use modern tools necessary for engineering practice routinely receives high ratings from students in about five classes, those three shown below for illustrative purposes plus CVEN 3708 Geotechnical Engineering 1 and CVEN 3246 Introduction to Construction; we have consistently met our minimum criteria.

Modern engineering tools: Student Ratings on Required Course FCQs (0-6)

Academic Year	CVEN 2012 Geomatics	CVEN 3323 Hydraulics	CVEN 4899 Design
2011-12	5.2	4.8	4.9
2012-13	5.0	5.0	5.3
2013-14	4.6	5.1	5.0
2014-15	4.4	4.9	5.1
2015-16	4.4	5.0	4.6, 5.2
2016-17	4.9	5.3	5.1

Outcome 13 [k] Senior Survey

Students rated their achievement of the outcome 'ability to use the techniques, skills, and modern engineering tools such as common software programs necessary for engineering practice'. While we have not failed to meet our minimum standard of 3.5, two assessment cycles showed this outcome to be of concern with only marginal satisfaction.

Senior Survey Avg rating 1-5 scale	Year	2011-12	2012-13	2013-14	2014-15	2015-16
# responses		*55*	*77*	*84*	*59*	*59*
Modern tools		3.6	3.9	3.9	3.7	3.6

<u>Summary</u>: The direct assessment data from the FE exam and senior design rubric show good knowledge of CU student of modern engineering techniques and tools. The indirect assessment metrics are good to marginal. Overall, CU civil engineering students have satisfied this outcome.

Outcome 14. Explain Concepts in Management, Business, Public Policy, and Leadership

Outcome 14 Senior Design Quiz

The capstone senior design course includes guest lectures on project management, public policy, and leadership and evaluates student knowledge of these topics via two to four questions on each topic as part of an individual quiz; however, student performance on the questions related to the different topics were not recorded separately from the overall performance in 2013-2016, so assessment data is not available except in spring 2017. The spring 2017 data shows that we failed to meet our goal that 80% of the students scored at an adequate or higher level (where lowest adequate score is earning 80% of the available points). The small number of questions and grading style for each question (right, half credit, or wrong) means that this assessment method has a limited ability to give a quality assessment of student knowledge (reflected by all of the students doing either superior, 90% or higher) or poor (70% or lower). Given the limited utility of this assessment method, it will likely be discontinued.

Capstone Design Course		Percentage of Students at Each Performance Level			
Quiz Topic	Year	Poor	Needs Improvement	Adequate	Superior
Project Management (3 questions)	Sp2017	23	0	0	77
Public policy (4 questions)	Sp2017	24	0	0	76
Leadership (2 questions)	Sp2017	28	0	0	72

Outcome 14 Direct Assessment: Student Performance on Homework

In the Professional Issues course, assignments relate specifically to business and public administration, public policy, and management vs. leadership. These assignments are used as embedded indicators of the level of student knowledge on these topics. For the technical elements graded on the assignments (excluding writing and format), the following percentages were converted into rubric scores below: >90% superior, 80-90% adequate, 70-80% needs improvement, <70% poor. The goal is for 80% or more of the students to perform at an adequate or higher level. We met this goal for the management/leadership topic in both 2015 and 2016. The business and public policy topics met our goal in 2015, but both just fell short of our goal (only 79% of the students adequate or better) in 2016. Changes are being considered in how these topics are taught to enhance students' knowledge and understanding.

Prof Issues Course		Percentage of Students at Each Performance Level			
Homework Topic	Year	Poor	Needs Improvement	Adequate	Superior
Business and public administration	F2015	0	5	11	84
	F2016	9	13	20	59
Public policy	F2015	5	5	5	84
	F2016	14	7	13	66
Management vs. Leadership	F2015	5	0	5	89
	F2016	0	5	5	89

Outcome 14 Student Ratings on Course FCQs

The students answer three questions related to this outcome on course FCQs: (1) understanding of business, public policy, and administration fundamentals; (2) role of the leader and leadership principles and attitudes; (3) elements of project management, construction, and asset management. The strongest coverage of these outcomes is in Introduction to Construction and Senior Design. Sufficient fulfillment of the business/public policy outcome was achieved in 4 of 6 years, leadership in 5 of 6 years, and project management in 5 of 6 years (based on meeting our minimum goal of 3 courses with average ratings above 4).

Business, public policy and administration, leadership, project management:
Student Ratings on Required Course FCQs (0-6)

Academic Year	CVEN1317 Intro CivE	CVEN 3246 Intro Constr	CVEN 4899 Sr Design	CVEN 4897 Prof Issues
2011-12	3.8, 4.1, 4.5	4.8, 4.7, 5.5 5.4, 5.3, 5.7	4.6, 5.2, 5.1	
2012-13	4.0, 3.9, 4.1	5.1, 4.8, 5.5 5.5, 4.5, 5.8	4.8, 5.2, 5.3	
2013-14	4.0, 4.1, 4.4	4.9, 4.8, 5.5 4.9, 5.0, 5.5	4.8, 5.0, 5.2	
2014-15	4.4, 4.4, 4.6	5.1, 4.7, 5.8 4.8, 4.8, 5.4	4.9, 4.9, 5.0	
2015-16	4.6, 4.8, 4.8	5.2, 4.9, 5.7 5.2, 5.1, 5.8	4.4, 4.7, 5.2 4.8, 5.1, 5.2	4.3, 3.8, 2.0
2016-17	3.8, 4.2, 3.9	5.1, 5.0, 5.6 5.0, 5.1, 5.7	4.5, 5.3, 5.3	3.9, 3.8, 2.9

Outcome 14 Senior Survey

For the civil engineering program outcome 'ability to explain basic concepts in management, business, public policy, and leadership' achievement initially fell short of our minimum standard, but more recently has just reached a minimal acceptable level. We expect student ratings of fulfillment of this outcome to improve in the future when all graduating seniors will have taken the new Professional Issues course.

Senior Survey Avg rating 1-5 scale	Year	2011-12	2012-13	2013-14	2014-15	2015-16
# responses		*56*	*77*	*83*	*57*	*59*
management, business, public policy, and leadership		3.3	3.4	3.5	3.5	3.3

<u>Summary</u>: The final student learning outcome was added to map to program specific criteria in civil engineering. It combines multiple elements, which complicates assessment. Work is underway to develop better direct assessment measures from the Introduction to Construction course. At present, evidence shows that we are not consistently meeting this outcome.

B. Continuous Improvement

Major Curriculum Revision
After the previous ABET review, the curriculum changed to its current format. The majority of these changes were motivated by feedback from the JEC process and student surveys, as well as an awareness of upcoming changes to the ABET EAC civil engineering program criteria to achieve greater alignment with the ASCE BOK2. The changes were explored for nearly an entire year by the curriculum committee and approved by a vote of the faculty at a special retreat that was held in May 2012. The changes made room in the curriculum to add a 2-credit Professional Issues course in the senior year, which would bolster students' knowledge around outcomes 7f ethics and professional responsibility, 10h societal context, 11i lifelong learning, 12j contemporary issues, and 14 civil engineering program-specific criteria. Based primarily on recommendations from the Structural Engineering and Structural Mechanics (SESM) JEC, the content of geomatics and engineering drawing were reduced from 6-credits to 3-credits. The changes also no longer required students to elect a concentration area in civil engineering, thereby keeping the focus on breadth in the bachelor's degree, in alignment with the ASCE BOK2. In addition, the changes increased the flexibility in the curriculum, allowing students more freedom to choose either technical or non-technical courses of interest, in alignment with educational motivation literature on self-determination theory.

7[f] Ethics and Professional Responsibility
The direct assessment data from student performance on the ethics and professional knowledge questions on the FE exam showed performance that did not meet our goals in AY 2013-14 and AY 2014-15. To enhance our students' knowledge of ethics, this topic was made a large focus in the CVEN 4897 Professional Issues course that is now required in the senior year (it was taught for the first time as a pilot in Fall 2015, and for all CVEN students in Fall 2016). The Professional Issues course includes a 50-minute lecture devoted to the ASCE code of ethics and other personal responsibilities to the public, environment, employers, and the profession. The students complete a 30-minute online quiz with FE-type multiple choice questions. They can repeat the practice quiz as many times as they like. The course also includes a more in-depth discussion of engineering ethics, devoting two weeks and a large homework assignment to this topic. Professional responsibility issues are also included as students are required to read the ASCE Body of Knowledge. We have found that students' performance on the ethics questions on the FE exam appears to be improving. We will continue to monitor this outcome.

8[g] Written Communication
Several JECs have mentioned that they believe that the communication skills of the students are weak and the curriculum should do more to encourage improved writing skills (this includes the 2014 Construction Engineering and Management JEC, 2015 Water/Environment JEC). This topic has been discussed in CEAE faculty meetings, and upon a proposal from CEAE is now being reviewed College-wide by the Undergraduate Engineering Council (UEC). In the meantime, individual CEAE faculty are trying to increase their emphasis on written communication within their CEAE courses. This includes Prof. Roseanna Neupauer using a more rigorous written communication grading rubric for laboratory reports in the required CVEN 3323 Hydraulics course, CVEN 3246 Introduction to Construction that includes a project with 30% of the grade based on writing (and includes instructor feedback on a draft of the report), and Prof.

Lupita Montoya including a small writing assignment within the required AREN 2110 Thermodynamics course. It is hoped that this infusion approach to writing-in-context may yield gains as students move through the curriculum.

8[g] Communicate via Drawings / 13[k] Modern Tools

The change in the curriculum which merged the topics of geomatics and engineering drawing into a single course 3-credit course was not found to be serving the students. The CEM JECs voiced a desire for more training of students in these topics. Also, marginal ratings were received for issues related to modern tools and communication via engineering drawings on the senior survey. Further, CVEN student comments on course FCQs identified shortcomings, e.g.:

> "In our drawing portion of the Geomatics class Spring 2014 semester, we first became familiar with the Revit program by recreating a 2D plot given to us in paper form on the Revit program. From this 2D drawing plot, we made an in class 3D model by filling in the proper topography given on the paper plot of a portion of our land and created a parking lot with an entrance, parking spaces, and parking bars. We also placed dimensions on our model and chose material types which to make our pad out of. We took 3D pictures of this concrete parking lot and calculated amount of materials required for this project. For the class final, we recreated this in class 3D modeling and parking lot on our own on a different portion of our initial 2D plot, and added several extra features such as walls, another entrance, and hills. The drawing class was a very good, however basic, introduction to the Revit program. With more time, I believe it would've been a complete introduction and we could have understood all of the functions of the program better. However, I felt the Geomatics portion was completely disorganized, and repetitive. The only thing we did all year was take sample surveying measurements, with no real direction or initiative, and not even use most of those measurements for any calculations. We barely did anything with altitudes; everything surveyed only concerned flat lands. All I learned was how to use survey equipment to take measurements, not actually what to do with those measurements."

Between summer and fall 2015, the CEAE Curriculum Committee and CEAE Chair decided that the combined course AREN 2830-3.0 Geomatics/Engineering Drawing had serious flaws, and continuing to require and offer it would be a disservice to the students. During the Fall 2015 semester, the curriculum committee discussed and approved several changes to the CVEN curriculum, including replacing the combined three-credit geomatics/drawing class with a full three-credit geomatics class, and replacing one free elective with a three-credit drawing class. CVEN students would have the option of taking AREN 1027 or CVEN 1027. The two courses would have the same structure, but the AREN course would use a vertical drawing tool (Revit) and the CVEN course would use a horizontal drawing tool (Civil3D). These changes were approved by the CEAE faculty on February 3, 2016, but too late to go into effect for the 2016-2017 catalog. Thus, students will be strongly advised to take both courses, using the drawing course as one of their free electives. The change will become official in the 2017-2018 catalog.

11[i] Lifelong Learning
The pass rates of civil engineering students on the FE exam have intermittently failed to meet our goal to be within 5% of the pass rates for civil engineering students nationally. The performance has been particularly weak since the switch to the online testing format. We believe this reflects a weakness in our lifelong learning outcome 11 [i]. This has been a concern among the CEAE faculty, with discussion in numerous faculty meetings, and our Joint Evaluation Committees. The problem has appeared to worsen with the change in the FE exam to the online format with a different set of topics on the civil engineering exam. Therefore, FE review is a prominent element in a new two-credit Professional Issues course that was added as a requirement into the CVEN curriculum. Within this course, students take a practice FE exam, identify their weaknesses, and then review those topics with assessment via quizzes. A second simulated FE exam is completed by the students and graded on performance. In all, FE exam activities comprise 25% of the course grade. In addition, there are lectures and a homework assignment that emphasize the importance of professional licensure, reinforcing the content in the first-year Introduction to Civil Engineering course. Other CEAE faculty have committed to infusing discussion of the FE exam and FE-type practice problems into their courses, including CVEN 3414 Fundamentals of Environmental Engineering and CVEN 3323 Hydraulics. The new Professional Issues course was taught for the first time in Fall 2015; a small number of students who elected to transfer to the new curriculum or transferred into the CVEN degree after the change in the catalog requirements took the new course. Starting in Fall 2016, all CVEN students are required to take the course in fall of their senior year. It is too early to tell if the curriculum change has yielded any benefits in the percentage of our students that pass the FE exam. That is because most our students take the exam in their final semester, which for the current cohort will occur in Spring 2017. However, the Spring 2017 performance results will not be available to us until July 2017; we will provide this information at the time of the ABET review visit.

12[j] Contemporary Issues
Assessment data has shown that outcome 12 [j] contemporary issues is being marginally met. The new Professional Issues course in the senior year is intended to contribute significantly to achieving this outcome, as well as providing direct assessment of achievement. Multiple issues can be defined as “contemporary.” We believe that understanding engineering economics is contemporary, given that economics plays a large role in civil engineering, particularly public investment in infrastructure. The ASCE Infrastructure Report Card is discussed in both the first-year introduction to civil engineering course and the senior professional issues course. Sustainability is another key contemporary issue; again, it is emphasized in both the first-year introduction to civil engineering course and the senior professional issues course. Sustainability is also touched on in the sophomore-year thermodynamics course (infused by Prof. Montoya). The junior level CVEN 3246 Introduction to Construction Management course also includes contemporary issues briefly in each lecture. Thus, there are multiple levels of infusion of this topic into the curriculum. We look forward to seeing the senior survey outcomes assessment data from 2016/2017 to see if students also recognize this in their ratings.

14 - Explain Concepts in Management, Business, Public Policy, and Leadership
Assessment data has shown that student fulfilment of outcome 14, that is related to some of the civil-engineering program-specific criteria, is weak. Of specific concern are the low scores from students’ self-assessment on the senior exit survey, which is used as an indirect assessment.

Some of these elements are included in the CVEN 3246 Introduction to Construction course that is required for all CVEN students and typically taken in fall semester junior year. Until now, direct assessment of students' knowledge has not been conducted in that course. Leadership is also included as a topic in the capstone design course, with a lecture and questions on the course quiz. However, given the "multiple barreled" nature of this outcome (which actually maps to 4 different topics), students may feel strong in some areas but weak in others. That cannot be determined from the senior survey data.

Information on business, leadership vs. management, and public policy are a large focus in the new CVEN4897 Professional Issues course. The topics each have about 1-week of in-class content (lecture, active learning), and a required homework assignment. As such, both the teaching and assessment methods in the course are still being revised. We do not yet have senior survey data from a year when all the graduating students will have taken the professional issues course (May 2017 graduates). We will continue working on this outcome, and try to improve its associated content in the Professional Issues course, as needed.

C. Additional Information

The FE exam serves as a direct assessment method for 7 of our 14 student outcomes. The civil engineering exam requirements from the NCEES, performance reports from the NCEES on the performance of CU civil engineering students, and the full FE summary spreadsheet will be available for examination at the time of the visit.

Student reports and presentations in the senior capstone design course are used as direct assessments for four student outcomes. The rubric used in the course to assess these outcomes is presented in Appendix E. The course dossier will include current and historical data from the course rubric. Further, a quiz is used in the course to assess student knowledge of five additional outcomes. An example of this quiz is included in Appendix E, and will also be available for examination in the design course dossier.

Assignments in other courses that are used to assess student outcomes— including laboratory reports and homework assignments from the Introduction to Civil Engineering course and the Professional Issues course— will be available for examination in files compiled for each relevant outcome, as well as the course dossiers.

CRITERION 5. CURRICULUM

A. Program Curriculum

The Civil Engineering curriculum is commonly presented to students, faculty, and other constituents as a so-called "Block Diagram". The block diagram lays out the expected and recommended order of courses to complete the requirements for the program in eight semesters (four academic years). The first semester is shown in the bottom row of the diagram, and subsequent semesters build to the final semester at the top. The block diagram indicates courses that are part of pre-requisite and co-requisite sequences in their proper order. Some courses are also offered only fall or spring semester, and those courses are shown in an appropriate location (and also denoted with a #). Students have opportunities to select a number of courses, including three Civil Engineering proficiency courses, five social science/humanities courses (S-H elective), two CEAE technical electives, and two technical electives. There are lists of acceptable courses for each of these choices. The CVEN proficiency courses come from a list of six options. The technical elective list is quite extensive; it is periodically reviewed by the curriculum committee and published online for students (http://www.colorado.edu/ceae/sites/default/files/attached-files/ceae_tech_elective_list_-_march_2015.pdf). Approved S-H electives are controlled by the HSS committee in CEAS. It includes courses offered by the Herbst Program of Humanities. It includes courses approved as part of the core curriculum of the College of Arts & Sciences in the topic areas of contemporary societies, human diversity, foreign language, historical context, ideals & values, literature & the arts, and United States context. Additional courses have also been approved (http://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements). The curriculum also includes two free (unrestricted) electives.

After the Block Diagram, the curriculum is also shown in Table 5-1. Courses have been listed from first to eighth semester, in the same recommended order shown in the Block Diagram. The maximum section enrollments for all courses in the program for the last two terms the course was taught have been included. Many courses only have a lecture. Other courses also include recitations or laboratories, so the enrollment for those types of scheduled meetings is also shown.

SEM	CR	CVEN BLOCK DIAGRAM					
8TH SEM (SPR)	16	CVEN **4899**-4 Senior Design Project (Senior standing) #	**Technical Elective**-3	**Technical Elective**-3	**Proficiency III** CVEN XXXX-3		**S-H Elective**-3 **(upper-level)**
7TH SEM (FALL)	17	**CVEN 4897**-2 Professional Issues	**CEAE Technical Elective**-3	**CEAE Technical Elective**-3	**Proficiency II** **CVEN XXXX-3**	**FREE ELECTIVE**-3	**S-H Elective**-3 **(upper-level)**
6TH SEM (SPR)	15	**CVEN 3227**-3 Probability Statistic & Decision for Civil Engrs. (JRs/SRs) #	**CVEN 3111**-3 Analytical Mechanics II (CVEN 2121, co-req APPM 2360) #	**Proficiency I** CVEN XXXX-3		**FREE ELECTIVE**-3	**WRTG 3030**-3 Writing on Science & Society (JR standing)
5TH SEM (FALL)	18	**CVEN 3246**-3 Intro. To Construction (JR or instructor consent)	**CVEN 3323**-3 Hydraulic Engineering (CVEN 3313) #	**CVEN 3525**-3 Structural Analysis (CVEN 3161)	**CVEN 3414**-3 Fund. of Env. Engr. (CHEN 1211, APPM 1360)	**CVEN 3708**-3 Geotechnical Engineering I (CVEN 3161)	**S-H Elective**-3
4TH SEM (SPR)	16	**APPM 2360**-4 Introduction to Linear Algebra & Differential Equations	**CVEN 3313**-3 Theoretical Fluid Mechanics (CVEN 2121) #	**CVEN 3161**-3 Mechanics of Materials I (CVEN 2121, co-req APPM 2360)	**AREN 2110**-3 Thermodynamics (PHYS 1110, co-req APPM 1360)		**S-H Elective**-3
3RD SEM (FALL)	15	**APPM 2350**-4 Calculus III for Engineers (APPM 1360)	**PHYS 1120**-4 **PHYS 1140**-1 Gen.Phys/Lab (PHYS 1110, co-req APPM 1360)	**CVEN 2121**-3 Analytical Mechanics I (PHYS 1110, co-req APPM 2350)		**CVEN 3698**-3 Engineering Geology OR **Other Basic Science*** #	
2ND SEM (SPR)	17	**APPM 1360**-4 Calculus II for Engineers (APPM 1350)	**PHYS 1110**-4 Gen. Physics I (co-req APPM 1350)	**CHEN 1310**-3 Intro Engr. Computing (co-req APPM 1350)	**AREN 1027-1** Engineering Drawing	**CVEN 2012-2**** Introduction to Geomatics (APPM 1350 or equiv.) #	**S-H Elective**-3
1ST SEM (FALL)	14	**APPM 1350**-4 Calculus I for Engineers (2yr HS Alg, 1yr Geom., 1/2yr Trig or approval by faculty advisor)	**CHEN 1211-4** Gen Chem for Engineers $ (1yr HS CHEM or Satis. In CHEM 1001 or CHEM 1021 & HS Alg)	**CHEM 1221-1** General Chemistry Lab for Engineers $	**GEEN 1400**-3 Engineering Projects OR **Basic Engineering Elective*** **	**CVEN 1317**-2 Introduction to Civil & Environmental Engineering # OR **COEN 1500******	

Table 5-1 Curriculum

Civil Engineering

Course (Department, Number, Title) All courses in the program by term starting with the first term of the first year and ending with the last term of the final year. [1 = first semester; 8 = final semester]	Course is Required (R), Elective (E) or a Selected Elective (SE) [1]	*Subject Area (Credit Hours)* Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other	Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
First Year, First Semester							
[1] CVEN 1317 Introduction to Civil & Environmental Engineering	R		*2*			*2016F, 2015F*	*74, 81*
[1] APPM 1350 Calculus 1 for Engineers	R	4				*2017S, 2016F*	*L 104, 123* *R 26, 26*
[1] CHEN 1211 General Chemistry for Engineers	R	4				*2017S, 2016F*	*L 100, 384* *R 35, 35*
[1] CHEM 1221 Engineering General Chemistry Lab	R	1				*2017S, 2016F*	*Lb 20, 21*
[1] GEEN 1400 Project Design or basic engineering elective	R		*3*			*2017S, 2016F*	*32, 33*
First Year, Second Semester							
[2] APPM 1360 Calculus 2 for Engineers	R	4				*2017S, 2016F*	*L 133, 118* *R 26, 26*
[2] PHYS 1110 General Physics 1	R	4				*2017S, 2016F*	*L 316, 339* *R 28, 29*
[2] CHEN 1310 Introduction to Engineering Computing	R		*3*			*2017S, 2016F*	*L 178, 231* *R 25, 25*
[2] CVEN 2012 Introduction to Geomatics	R		*2*			*2017S, 2016S*	*L 97, 105* *Lb 20, 20*
[2] AREN 1027 Engineering Drawing	R		*1*			*2017S, 2016F*	*L 66, 72* *Lb 44, 46*
[2] Social science or humanities elective	SE			*3*			*~200*

Course (Department, Number, Title) All courses in the program by term starting with the first term of the first year and ending with the last term of the final year. [1 = first semester; 8 = final semester]	Course is Required (R), Elective (E) or a Selected Elective (SE) [1]	*Subject Area (Credit Hours)* Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other	Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
Sophomore (Second) Year, Semester 3							
[3] APPM 2350 Calculus 3 for Engineers	R	4				*2017S, 2016F*	*L 115, 133 R 26, 26*
[3] PHYS 1120 General Physics 2	R	4				*2017S, 2016F*	*L 331, 272 R 29, 29*
[3] PHYS 1140 Experimental Physics 1	R	1				*2017S, 2016F*	*L 336, 335 Lb 16, 18*
[3] CVEN 2121 Analytical Mechanics 1	R		*3*			*2017S, 2016F*	*62, 106*
[3] CVEN 3698 Engineering Geology OR other basic science	SE	3				*F2016, F2015*	*52, 41*
Sophomore (Second) Year, Semester 4							
[4] APPM 2360 Intro. to Differential Equations with Linear Algebra	R	4				*2017S, 2016F*	*L 145, 148 R 26, 27*
[4] CVEN 3313 Theoretical Fluid Mechanics	R		*3*			*S2017, S2016*	*105, 92*
[4] CVEN 3161 Mechanics of Materials 1	R		*3*			*2017S, 2016F*	*L 79, 38 Lb 53, 38*
[4] AREN 2110 Thermodynamics	R		*3*			*S2017, F2016*	*56, 72*
[4] Social science or humanities elective	SE			*3*			*~200*
Junior (Third) Year, Semester 5							
[5] CVEN 3246 Introduction to Construction	R		*3*			*2017S, 2016F*	*49, 62*
[5] CVEN 3323 Hydraulic Engineering	R		*3*			*F2016, F2015*	*70, 75*
[5] CVEN 3525 Structural Analysis	R		*3*			*2017S, 2016F*	*30, 83*
[5] CVEN 3414 Fundamentals of Environmental Engineering	R		*3*			*2017S, 2016F*	*65, 74*
[5] CVEN 3708 Geotechnical Engineering 1	R		*3*			*2017S, 2016F*	*L 16, 50 Lb 15, 20*
[5] Social science or humanities elective	SE			*3*			*~200*

Course (Department, Number, Title) All courses in the program by term starting with the first term of the first year and ending with the last term of the final year. [1 = first semester; 8 = final semester]	Course is Required (R), Elective (E) or a Selected Elective (SE) [1]	*Subject Area (Credit Hours)* Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other	Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
Junior (Third) Year, Semester 6							
[6] CVEN 3227 Probability, Statistics, and Decision	R		*3*			*S2017, S2016*	*105, 94*
[6] CVEN 3111 Analytical Mechanics 2	R		*3*			*S2017, S2016*	*76, 74*
[6] WRTG 3030 Writing on Science & Society	R			*3*		*2017S, 2016F*	*19, 19*
[6] CVEN xxxx civil engineering proficiency course	SE		*3*				*~66, 77*
[6] free elective	E				*3*		
Senior (Fourth) Year, Semester 7							
[7] CVEN 4897 Professional Issues in Civil Engineering	R		*2*			*2016F, 2015F*	*56, 19*
[7] CVEN xxxx civil engineering proficiency course	SE		*3*				*~66, 77*
[7] CVEN xxxx civil engineering technical elective	SE		*3*				*~70, 80*
[7] CVEN xxxx civil engineering technical elective	SE		*3*				*~70, 80*
[7] Social science or humanities elective (upper level)	SE			*3*			*~80, 80*
[7] free elective	E				*3*		
Senior (Fourth) Year, Semester 8							
[8] CVEN 4899 Civil Engineering Senior Project Design	R		*4√*			*2017S, 2016S*	*64, 38*
[8] CVEN xxxx civil engineering proficiency course	SE		*3*				*~66, 77*
[8] Technical elective	SE		*3*				*~100, 100*
[8] Technical elective	SE		*3*				*~100, 100*
[8] Social science or humanities elective (upper level)	SE			*3*			*~80, 80*
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		33	*71*	*18*	*6*		
OVERALL TOTAL CREDIT HOURS FOR COMPLETION OF THE PROGRAM							
PERCENT OF TOTAL		26%	*55%*	*14%*	*5%*		
Total must satisfy either credit hours or percentage	Minimum Semester Credit Hours	32 Hours	48 Hours				
	Minimum Percentage	25%	37.5 %				

1. **Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group.
2. For courses that include multiple elements (lecture, laboratory, recitation, etc.), indicate the maximum enrollment in each element. For selected elective courses, indicate the maximum enrollment for each option. L = lecture, Lb = lab, R = recitation; if no designator, the course has the same enrollment in all contact hours (typically, lecture).

<u>For CVEN proficiency courses, students choose 3 from the following courses (last 2 terms offered; enrollment):</u>
CVEN 3256 Construction Equipment and Methods (S2017, F2016; 53, 55); √ = significant design content
CVEN 3424 Water and Wastewater Treatment (S2017, S2016; 66, 77); √ = significant design content
CVEN 3718 Geotechnical Engineering 2 (S2017, F2016; L: 11, 21; Lb: 7,13, 13); √ = significant design content
CVEN 4333 Hydrology (S2017, F2016; 58, 28)
CVEN 4545 Steel Design (S2017, S2016; 45, 39) or CVEN 4555 Reinforced Concrete Design (F2016, F2015; 44, 54); √ = significant design

Curriculum Alignment with Program Educational Objectives

The overall philosophy of the Civil Engineering curriculum is to provide all students with a broad foundation in engineering, followed by breadth across the various sub-discipline areas of civil engineering, and then allow the students choice to build additional breadth or depth in civil engineering, as well as related technical and/or non-technical areas (via technical elective, social science/humanities (S-H) electives, and free electives). This strong grounding in fundamentals and breadth enables the students to take their careers in multiple directions, and solve problems that generally cross sub-disciplinary boundaries.

The program objectives are linked to desired outcomes, as shown previously in section 3B. The outcomes are fulfilled by various required courses in the curriculum, as described below. For example, all courses contribute to the knowledge and skills required for our alumni to be successfully employed in engineering, science, or technology careers (objective 1). The alignment of the curriculum with the program educational objectives is summarized below.

Objective	1st yr courses	2nd yr courses	3rd year courses	4th year courses	Notes
1. Successfully employed	All provide foundation	All provide foundation	All provide foundation	All provide foundation	Proficiency structure
2. Management or leadership			Intro Constr	Prof issues Senior design	
3. Continual learning				Senior design Prof issues	
4. Professional licensure	Intro CivE		Intro Constr	Prof issues Senior design	
5. Benefit communities	Intro CivE Social sci/humanities electives	Social sci/humanities electives	Fund. Env Eng Social sci/humanities electives	Prof issues Senior design Social sci/humanities electives	

Students are introduced to civil engineering in the Introduction to Civil Engineering course in the first semester. Then, students work to build basic science and mathematics knowledge, skills in geomatics/drawing, and breadth in humanities and social sciences in their other first year courses. These build to the engineering science courses that are largely in the sophomore and early junior year. The required fundamental courses in the breadth of civil engineering disciplines are taken fall semester junior year, from which the students are prepared to select their desired three areas of proficiency and CEAE electives.

The preparation of our students to assume management and/or leadership roles after graduation (objective 2) is largely accomplished through team-based courses, and specifically the Introduction to Construction course in spring junior year, Professional Issues course in fall senior year, and the capstone design course in spring senior year. Team experiences are included in nine required courses, and among these opportunities students are likely to assume management and/or leadership roles. Alternatively, they experience different management and leadership styles in these groups, and develop an appreciation for more and less effective strategies.

Our students have ample opportunity to see why continual learning is important, and demonstrate the ability to teach themselves new material in the largely self-directed environment of the capstone design course. The courses that focus on life-long learning (contributing to Outcome 11) are key to preparing our alumni to achieve the continual learning objective. Students are introduced to the importance of lifelong learning in the Introduction to Civil Engineering course in the first semester, and these ideas are reinforced in courses such as Introduction to Construction (junior year), and Professional Issues and capstone design (senior year).

The importance of pursuing professional licensure, to prepare graduates to achieve objective 4, is particularly emphasized in three key courses in the curriculum: Introduction to Civil Engineering (first semester), Introduction to Construction (fall junior year), Professional Issues (fall senior year), and Senior Design (spring senior year).

We expect graduates to be providing benefit to communities (objective 5). Their humanities and social science electives help contribute to this goal along with courses that emphasize the impact of engineering on society (outcome 10, including Introduction to Civil Engineering, Fundamentals of Environmental Engineering, Professional Issues, and Senior Design).

Mapping Curriculum to Student Educational Outcomes

All the required CVEN and AREN courses in the CVEN curriculum have been mapped to the extent to which they contribute to each of the 14 student outcomes, based on faculty ratings (per the 2-page course syllabi in Appendix A): large contribution (red), medium (orange), small (yellow), and none. The average student ratings on the course FCQs from the previous two rating semesters which range from 0 to 6 are shown as numbers in the figure below. Note that ratings vary by semester, and a few outcomes vary a lot when different instructors teach the course. Most instructors under-rate contributions to outcomes, in comparison to student ratings.

Missing from the table are required courses in the curriculum outside of engineering. They primarily contribute to outcome 1 [4 semesters of calculus and math; 2 semesters of physics, 1 semester of chemistry], outcome 13 [Engineering Computing], and outcome 8 [Writing on Science & Society]. The humanities and social science electives [15 credits] contribute to outcome 10.

The three proficiency courses and two civil engineering electives taken by the students also contribute significantly to the achievement of the outcomes. But these will vary based on the specific courses selected by the students. The mapping of the proficiency courses and common civil engineering electives to the 14 outcomes is shown in an additional table below.

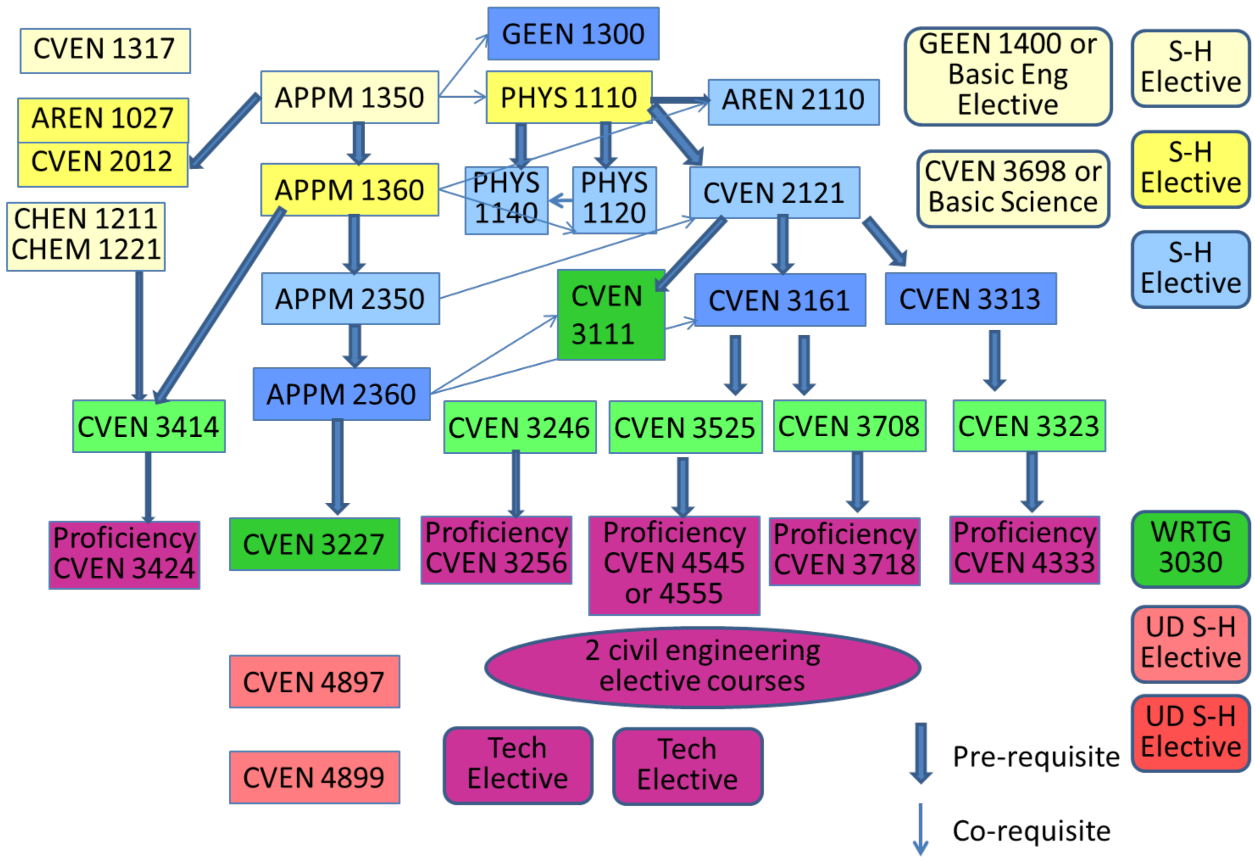
Alignment of Required engineering courses in the CVEN degree mapped to Student Outcomes [faculty ratings: red = large, orange = medium, yellow = small]

	Student Outcomes													
Courses [semester]	**1A**	**2B**	**3B**	**4C**	**5D**	**6E**	**7F**	**8G**	**9G**	**10H**	**11I**	**12J**	**13K**	**14cv**
CVEN 1317-2 [1]														
AREN 1027-1 [2]														
CVEN 2012-2 [2]														
AREN 2110-3 [3]														
CVEN 2121-3 [3]														
CVEN 3161-3 [4]														
CVEN 3313-3 [4]														
CVEN 3525-3 [5]														
CVEN 3323-3 [5]														
CVEN 3414-3 [5]														
CVEN 3708-3 [5]														
CVEN 3246-3 [5]														
CVEN 3111-3 [6]														
CVEN 3227-3 [6]														
CVEN 4897-2 [7]														
CVEN 4899-4 [8]														
Total # L courses	12L	3L	5L	2L	2L	8L	2L	5L	1L	1L	2L	1L	9L	1L
Total # M courses	0M	2M	1M	2M	2M	3M	3M	1M	0M	7M	9M	2M	3M	2M

Alignment of civil engineering proficiency courses with student educational outcomes [faculty ratings: red = large, orange = medium, yellow = small]

	Student Outcomes													
Courses	**1A**	**2B**	**3B**	**4C**	**5D**	**6E**	**7F**	**8G**	**9G**	**10H**	**11I**	**12J**	**13K**	**14cv**
CVEN 3256 Con EqMth	red		orange	red	yellow	orange	orange	orange	orange	yellow	yellow	orange	orange	orange
CVEN 3424 W/WW	red	yellow	yellow	red	orange	red	yellow	yellow		yellow	orange	orange	orange	
CVEN 3718 Geotech2	red	orange	orange	yellow	yellow	red	orange	orange			yellow		orange	
CVEN 4333 Hydrology	red	yellow	red	orange		red	yellow	orange		orange	red	orange	red	
CVEN 4545 Steel Dsn	yellow			red			yellow				yellow			
CVEN 4555 Reinf Conc	yellow			red			yellow				yellow			

We also created a flowchart that illustrates the prerequisite structure of the program's required courses.



Curricular Areas and General and Program Criteria

The ABET basic-level general criteria require that a minimum of 32 credit hours or 25% of the total credit hours must be in the curricular area of math and basic sciences and that a minimum of 48 credit hours or 37.5% of the total credit hours must be in the curricular area of engineering topics. Table 5-1 shows that the CVEN curriculum meets these requirements.

Math and basic sciences: Table 5-1 shows that the program contains sufficient coverage of the math and basic science requirements, with 33 credits or 26% of the curriculum. These are courses from applied math (APPM), chemistry/chemical engineering, physics, and a basic science course (which may be engineering geology or other courses).

Engineering topics and design: Table 5-1 also shows that the program contains sufficient coverage to meet the engineering topics requirement, with 71 credit hours or 55% of the curriculum devoted to these topics. The table also shows which of these courses contain a large amount of design (an additional 2 required courses contain a medium amount of design; and a minimum of two of the proficiency level courses selected by students will also contain a large design component; see evidence in the colored mapping tables).

General education: The curriculum provides 18 credits of humanities and social sciences coursework, including 6 credits that are upper-division and an upper-division writing course. The College supports this activity by making available a humanities advisor to students to help them select a sequence of courses consistent with their interests. The College also provides a listing of approved courses for these electives (see http://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements) to ensure that the courses have sufficient quality and complement the technical portions of the curriculum; in general, courses that are “skills” oriented are not approved for these electives. Instead, the College’s list focuses on courses with a broad view of history, literature, and the humanities. Most these courses are approved as College of Arts & Sciences (A&S) core courses, and as such undergo scrutiny from A&S to ensure quality. Courses beyond the A&S core that are approved for engineering students are reviewed and approved by the College’s Undergraduate Education Council. Students are encouraged to pick an area of humanities or social science and devote their humanities electives to courses in that single area. Many also choose to take advantage of the College’s Herbst Program of Humanities for Engineers, described in Appendix D.

Other: The curriculum revisions that were voted in by the CEAE faculty in 2012 included six-credits of free electives. These credits were classified as “other”. They may be technical or non-technical courses. They provide students with a small amount of autonomy to customize their college experience. They may include study abroad courses, courses that contribute to a minor or certificate, etc.

In addition to the basic-level criteria, ABET specifies additional civil engineering program criteria, which are presented separately later in the Program Criteria section.

Major Design Experience

The major design experience taken by civil engineering students in their senior year before they graduate is fulfilled through CVEN 4899 Civil Engineering Senior Design (4 credits). This course provides students the opportunity to “practice their profession” in a simulated real world setting. Senior Design is the culmination of the civil engineering program which challenges students to combine their academic knowledge with practical considerations to solve “real-world” engineering problems that are subject to constraints including cost, schedule, technical, regulatory, and societal. The faculty members supporting this course provide little instruction in terms of what is common in most undergraduate classes (i.e. few lectures). Instead, the faculty members are to be used as a resource to support student teams during the process of designing and planning the project. One faculty member serves as an overall course coordinator, and additional faculty members representing each sub-discipline provide individualized mentoring on technical aspects. Guest speakers from industry join multiple classes to provide specific technical instruction as it relates to the project each year. Student teams are issued a Request for Proposal (RFP) at the beginning of the semester, mimicking a real-world design-build competition. Teams compete to win the mock design-build contract, chosen by the client and faculty. In preparing their proposals, student groups produce three separate major deliverable packages that include written reports, drawings and presentations for the first three (3) design stages of a project: Conceptual Design, Schematic Design and Design Development. The following list represents the typical deliverables required from each group:

1) General
    - Site Concept Plan
    - Written narratives with design calculations
    - Design alternatives and cost saving recommendations
    - Drawing package – The following list of drawings represents the minimum sheets to be provided. Additional sheets may be identified as the design progresses.
        - G1.X - Cover sheet, vicinity map and drawing index
        - C1.X - Site Concept Plan
        - C1.X - Demolition Plan
        - C2.X – Grading and Drainage Plan
        - C2.X - Site Sections if necessary
        - C2.X - Erosion Control Plan and Details
        - C2.X – Paving Plan
        - C3.X - Utility Plan
        - C4.X – Retaining Wall Elevation and Details (if applicable)
        - C5.X – Paving Details (Parking, curb/gutter, cross pans)
        - S1.X – Foundation Plan
        - S1.X – Framing Plans
        - S1.X – Other Structural Plans (if applicable)
        - S2.X – Structural Elevations
        - S3.X – Foundation Details
        - S3.X – Section Details
        - S3.X – Slab and Deck Details
        - S5.X – Typical Connection Details
        - P3.X – Plumbing riser diagram (if applicable)
    - Pavement design (parking), curb and gutter and cross pan design
2) Water
    - Stormwater design
    - Stormwater quality and quantity analysis
    - Potable/fire water design
    - Irrigation design (if applicable)
    - Hydraulic analysis
        - Map of flood depth and flood plain
3) Geotech
    - Fill specifications
    - Grading plan
    - Foundation design
    - Retaining wall design (if applicable)
    - Slope stability analysis (if required)
    - If fill is required, an evaluation of potential borrow locations

* Geotech and structural engineering coordination required to perform complete design

4) Structural
   - Structural design – substructure and superstructure

   * Geotech and structural engineering coordination required to perform complete design
5) Construction
   - Detailed cost estimate (design and construction) for full site development with quantity takeoff
     - Cost of Work shall include all work designed by your team plus assumptions for other site utilities (electrical, sanitary sewer, gas, teledata), earthwork and landscaping.
     - Value Engineering / Project Alternatives
   - Design and Construction Schedule
   - Formwork design for all concrete items noted above by structural engineer
   - Anticipated equipment list (all equipment, no hand tools)
   - Erosion Control Plan
   - Site Logistics and Phasing Plans

The specific projects vary from semester-to-semester. Recently they have been real projects of interest to local municipalities and non-profit groups. The specific objectives for the course are:

1. Integrate the technical sub-disciplines of structural, geotechnical, water resources and construction to create a professional-level solution to the assigned project problem.
2. Gather relevant data, understand client needs, identify constraints, and identify and use applicable regulations, codes and standards.
3. Create feasible alternative designs and carry out value engineering analysis.
4. Prepare increasingly detailed designs and construction planning that satisfies the Owners goals and project's constraints while also conforming to relevant codes and regulations.
5. Prepare design documentation including design rationale and intent, design details and integrated project planning, scheduling and construction cost analysis to support each design stage.
6. Complete primary components of contract documents for client as well as basic specifications.
7. Present ideas, concepts and designs in a professional format to the client from the perspective of an engineering firm attempting to win a design-build contract.
8. Work in multi-disciplinary teams and in interdisciplinary formats as appropriate during different phases of the assignment.

Teams are typically comprised of 4 to 6 students. The course also includes discussion of a variety of professional issues, which are facilitated via guest speakers with outcomes documented through a quiz at the end of the semester.

Cooperative Education

Cooperative education is not allowed to satisfy curricular requirements addressed by the general or program criteria.

Course Syllabi

In Appendix A, a syllabus is included for each course used to satisfy the mathematics, science, and discipline-specific requirements required by Criterion 5 and applicable program criteria. Further, courses that are commonly taken by civil engineering students, including all courses that count as proficiency courses and some additional courses are included.

CRITERION 6. FACULTY

A. Faculty Qualifications

There are 43 tenured/tenure-track faculty (24 Professors, 8 Associate Professors and 11 Assistant Professors) and 5 Senior/Full-time Instructors in the CEAE department. These faculty members are distributed among six specialty "groups" (see table below). See Table 6-1 for the qualifications of these faculty members, presented alphabetically with the exception of the building systems faculty, who are listed last due to their small contribution to the civil engineering degree program. (Table 6-2 gives the approximate percentage each individual devotes to civil engineering, again with the building systems faculty presented last). The geotechnical faculty contribute almost solely to Civil Engineering. The construction and structures faculty contribute about equally to both the Civil and Architectural Engineering programs. The water resources faculty contribute about equally to the Civil and Environmental Engineering programs. Many of the environmental engineering faculty contribute little to the Civil Engineering program, primarily teaching courses for the Environmental Engineering program. The building systems group contributes little to the Civil Engineering program, being primarily associated with the lighting/electrical/mechanical areas of Architectural Engineering. All CEAE faculty vote on objectives, outcomes, and curriculum matters, and as such have some contribution to the civil engineering program.

Specialty	Approx. % to Civil	Full professors	Associate Professors	Assistant Professors	Senior / Full Time Instructors
Geotechnical	100	4	1	3*	0
Water Resources	50	4	1	2	0
Structures	50	3	2	3	0
Construction	50	3	2	0	1
Environmental	20	7	2	2	2
Building Systems	*5*	*3*	*0*	*1*	*2+*
Total		24	8	11	5
Adjusted civil		~10.5	4	6*	1.5

+ *Includes Walter Beamer who resigned in Jan. 2017; position in process of being filled*

* *One started January 2017*

Four of the tenured/tenure-track faculty have their salaries rostered in the graduate school, and differential teaching responsibilities as a result (2 Professors, 1 Associate Professor, 1 Assistant Professor). One new faculty member started in January 2017. Six faculty members are affiliated with Research Institutes as Fellows or affiliated faculty (2 CIRES, 3 INSTAAR, RASEI 1 fellow/3 affiliates). The faculty includes high diversity, with 11 women T/TT (26%) and 1 senior instructor (20%) on the faculty, and three faculty from underrepresented minority population (7%). Currently, seven faculty members in CEAE hold endowed chairs (e.g. K. Stanton Lewis Chair of Construction Engineering and Management; Mortenson Chair in Global Engineering) and one professor and one Senior Instructor have professorships (Denver Business Challenge Professorship; Petry Professorship). Five faculty members have received NSF CAREER awards. Three faculty members are in the National Academy of Engineering (NAE). Twenty faculty members are fellows of major professional societies nationally, and three are fellows internationally. (Note: research professors (2) and scholars-in-residence that are associated only with the graduate program (2) are not included.)

Our faculty have been recognized for teaching excellence and educational research. Roseanna Neupauer received the 2006 ExCEED New Faculty Excellence in Teaching Award from the American Society of Civil Engineers (ASCE), the 2008 Charles A. Hutchinson Memorial Teaching Award, the 2010 Peebles Innovation in Teaching Award from CU's College of Engineering and Applied Science (CEAS), and the 2011 Boulder Faculty Assembly Excellence in Teaching Award from the CU-Boulder campus. She is also a President's Teaching Scholar. Prof. Joseph Ryan won the 2010 Outstanding Faculty Advisor Award from our College. Assoc. Professor Bielefeldt won the Best Overall Conference Paper Award from the American Society for Engineering Education (ASEE) twice for her papers presented at the 2009 and 2015 annual conference.

B. Faculty Workload

A normal tenure-track faculty member in the College is evaluated based on an allocation of 40% research, 40% teaching, and 20% service. These weightings can be changed if desired by the faculty member and if approved by the Department Chair and Dean. The standard teaching load in CEAE for research-active tenure-track faculty is three courses per year (for typical 3-credit courses). It is expected that these courses include at least one undergraduate course. The faculty members with appointments rostered in the graduate school teach two courses per year (Goosef, Livneh, McKnight, Pfeffer). The full-time senior instructors typically teach five courses per year. CEAE faculty instructional offerings generated 13,726 undergraduate and graduate student credit hours in the 2015-2016 academic year. The courses taught by our faculty comprise the majority of three different undergraduate majors: Civil Engineering, Architectural Engineering, and Environmental Engineering. The faculty workload is summarized in Table 6-2.

The annual research expectations of a tenure-track faculty member in CEAE with a typical research/teaching/service allocation would typically include 4 reviewed journal publications, 3-4 conference or invited presentations, $150,000-$200,000 in research expenditures, and 4-6 supervised graduate students (these are the approximate median values for T/TT faculty in CEAE in the 2016 calendar year). The annual service expectations would typically include contributions to several internal committees within the departmental, college, or campus, participation in national and international professional societies, and editorial review for professional journals.

C. Faculty Size

Faculty Size and Undergraduate Teaching

There is an adequate faculty size to teach and mentor civil engineering students, as shown above. The table below shows the number of Full Time Equivalent (FTE) Faculty, student credit hours (SCH) taught by CEAE faculty, and total number of undergraduate students. CEAE has been below the CU CEAS average for number of student credit hours (SCH) per faculty from 2013 and forward; CEAE is currently at our lowest level in 6 years. SCH are a good metric since our faculty teach courses that serve civil engineering, architectural engineering, and the bulk of the environmental engineering degree.

Fall Semester:	2011	2012	2013	2014	2015	2016
Full Time Equivalent faculty CEAE	36.5	39.0	39.5	40.0	40.0	42.0
SCH, all CEAE	17,366	16,394	15,425	13,497	13,666	13,164
CEAE SCH/Faculty	476	420	391	337	342	313
CU CEAS College SCH/Faculty	419	396	410	435	457	474
# civil engineering undergraduate students	298	292	284	252	267	254
# civil eng. equiv. faculty, approx.	19	20	20	21	21	22

As shown in the table below, the number of FTE faculty in the CEAE department has increased steadily over the past six years. The number of tenure line faculty budgeted elsewhere has remained fairly constant at 3 to 5, while the number of tenure-line faculty (w/o tenure line budgeted elsewhere) has increased from a low of 33 in 2012 to the current high of 38. The number of instructional faculty increased the most, from only 2 in 2011 to 8 currently. This includes instructors to fill vacancies due to sabbatical or in-process hires.

Fall Semester	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
# Faculty FTE Budgeted (Fac)	36.5	39.0	39.5	40.0	40.0	42.0
# Tenure-line Faculty (w/o TBE)	34	33	36	38	37	38
# Tenure-Line Budgeted Elsewhere (TBE)	5	3	3	3	4	4
# Instructional Faculty	2	5	5	7	8	8

In addition to faculty and senor instructors, some individuals are hired to teach specific courses. This generally occurs due to a sabbatical of a tenured faculty member or during the time the department is trying to fill a faculty vacancy. Occasionally, post-doctoral researchers or Ph.D. students who are building their teaching skills will teach courses under the mentoring supervision of their advisor. The Engineering Drawing course is the only required course that is routinely taught by individuals from outside the department. The table below summarizes the individuals who have been hired to teach courses required for civil engineering students in recent years (and proficiency courses), their qualifications, courses that they have taught, which semester(s), and average student ratings on the FCQs. The FCQ ratings are on a scale of 1-6 [1 = lowest, 6 = highest], and results for three questions are reported below: course overall, instructor overall, and “how much you learned in the course”.

Non-CEAE Faculty Teaching CVEN required or proficiency courses

Name	Qualifications	Courses Taught, semesters [FCQs on scale of 1-6]
Lance Cayko	Master's Architecture 2008 from North Dakota State University; licensed architect in CO 2015; Project Manager with Studio H:T (1 yr); owner and co-founder of F9 Productions (2009) residential BIM projects	AREN 1027 Engineering Drawing, F2013-Sp2016 [Course 4.1-5.2, instructor 4.3-5.2, amount learned 4.6-5.5]
Alex Gore	Master's of Architecture and Masters Degree in Construction Management, North Dakota State University; founder and co-owner of F9 Productions (2009-present) serving as designer and project manager for multiple residential and commercial BIM projects.	AREN 1027 Engineering Drawing, F2013-Sp2016 [Course 4.1-5.2, instructor 4.3-5.2, amount learned 4.6-5.5]
Milan Halek	Senior instructor emeritus with 40 yrs teaching experience at CU; Licensed Land Surveyor in Colorado; returned from retirement to teach.	CVEN 2012 Introduction to Geomatics. Sp 2016 [Course 4.5, Instructor 5.1]
Jeff Keely, PE	BS and MS Civil Engineering Univ. Washington; Colorado Dept. of Transportation (since 2007); design and consulting engineer (12 yrs)	CVEN 2121 Analytical Mechanics I, summer 2015, summer 2014 [Course: 4.7-5.0, Instructor: 5.2-5.3]
In Ho Cho	PhD Civil Engineering, California Institute of Technology; BS & MS Civil Engineering, Seoul National University, South Korea; instructor during Willis Research Fellowship at CU; expertise in computational science, structural analysis, seismology, and big data approaches to earthquake engineering	CVEN 2121 Analytical Mechanics I, Fall 2013 [Course: 5.0, Instructor 5.4] CVEN 3161 Mechanics of Materials I, Spr 2013 [Course: 4.9, Instructor: 5.3] CVEN 3525 Structural Analysis, Spr 2014 [Course: 4.2, Instructor 4.9]
Ryan Novak	BS Civil Engineering University Wisconsin, MS Civil Engineering CU 2005; project manager at UOP (4 yrs) and ERDMAN (3 yrs); Assistant Professor of Building Construction Management, University of Wisconsin – Platteville (4 yrs)	CVEN 3256 Construction Equipment and Methods (proficiency), Summer 2015 [Course: 4.7, Instructor: 4.9] CVEN 3246 Introduction to Construction, Spring 2015, [Course: 4.3, Instructor: 4.0]
Masoud Arshadi	BS Civil Engineering Sharif University of Technology 2008; PhD Civil Engineering CU 2013;	CVEN 3313 Theoretical Fluid Mechanics, spring 2015 [Course: 3.8, Instructor: 4.1]

Name	Qualifications	Courses Taught, semesters [FCQs on scale of 1-6]
Mike Soltys	P.E., Ph.D. 2013 CU Civil Eng. ~2 yrs as Engineer Diver at Collins Engineers, Inc; research assistant at Clemson U for 8 months, Graduate Research Assistant at CU in PhD program for 5 yrs. prior to serving as lecturer	CVEN 3323 Hydraulic Engineering, Fall 2012 [Course: 4.9, Instructor: 4.6]
Alison Ling	Co-taught course in the final semester of her PhD at CU (4 yrs in program prior to teaching); previous engineering internships at City of Bloomington and Barr Engineering, lecturer at Beijing City University, research assistant at University of Minnesota, Tsinghua University, and EAWAG.	CVEN 3414 Fundamentals of Environmental Engineering, F2013 [Course 4.5-4.6, instructor 4.9-5.0]
Austa Parker	Co-taught course after 2-yrs in PhD program at CU; previous BS chemistry Clemson and MS environmental engineering at CU; WASH volunteer in Haiti	CVEN 3414 Fundamentals of Environmental Engineering, F2013 [Course 4.5-4.6, instructor 4.9-5.0]
Jeff Writer	Teacher Certification from CU 1997; PhD CU 2010; Research Hydrologist at U.S. Geological Survey for over 5 yrs; additional work experience as Environmental Engineer at ERM-Rocky Mountain (2 yrs) and PTI Environmental Services (4 yrs)	CVEN 3414 Fundamentals of Environmental Engineering, F2012 [Course 4.3, Instructor: 4.8]
Lan Nguyen	Earned PhD in structural engineering from CU in May 2014. She worked as a structural engineer at Aero Solutions LLC from 2011-2013, including designing tower structural elements such as foundations and upgrades for stability. As a graduate research assistant she design reinforced concrete frames and masonry shear wall panels. She has since earned her P.E. license.	CVEN 4555 Reinforced Concrete Design (proficiency), Fall 2014 [Course: 4.9, Instructor: 5.5]

Faculty-Student Interactions

CEAE faculty members are actively involved in advising and mentoring students in the civil, architectural, and environmental engineering programs. Normally each faculty member advises 6 to 20 undergraduate civil engineering students, meeting individually with each advisee in each semester of their junior and senior year. Details of the student academic advising have been provided earlier in the section on Criterion 1D. Faculty help students prepare for engineering careers by finding internships, reviewing student's resumes and bringing professional colleagues to meetings of student societies, special seminars and to classes as guest speakers. Through supervision of undergraduate research opportunities and independent study projects, faculty encourage many undergraduate Civil Engineering students to continue their studies at the Masters and even doctoral level in Civil Engineering, either at the University of Colorado or other universities.

Faculty members advise student societies that primarily serve civil engineering students such as Chi Epsilon and student chapters of professional societies such as the Association of General Contractors (AGC), the American Society of Civil Engineers (ASCE), and the Society of Hispanic Professional Engineers (SHPE). One Civil Engineering faculty member founded Engineers Without Borders (EWB), with the first student chapter at the University of Colorado, Boulder. EWB has engaged students to work with practitioners to help communities in developing countries with projects for sustainable infrastructure for water, sanitation, housing, and transportation. This concept of outreach education and service learning started here at the University of Colorado Boulder and it has captured the enthusiasm of many engineering students. Indeed, there are now EWB student chapters at about half of all engineering programs throughout the US. CEAE faculty also advise a student chapter of Bridges to Prosperity (B2P) and are currently working with two international communities on bridge design. Thus, CEAE faculty members engage with students in a variety of co-curricular settings.

University Service Activities

Each faculty member typically serves on at least one standing Department Committee (Graduate, Curriculum, Operations, Computing, Facilities, Executive). In addition, faculty members serve on dozens of committees at the College and University level for developing curriculum, program evaluation, searches for new faculty and administrators, promotion, awards and fellowships, etc. Prof. Keith Molenaar is the Associate Dean for Graduate Programs in the College and will transition to the Associate Dean for Research in summer 2017. Prof. Paul Chinowsky is serving as the Associate Vice Provost for Student Success. Prof. R. Scott Summers serves as the Director of the College's interdisciplinary Environmental Engineering BS program. Prof. Neupauer serves on the Boulder Faculty Assembly. Faculty resumes in Appendix I-B show the number and diversity of faculty service to the University community.

Professional Service and Interaction with Practitioners

Most CEAE faculty members are involved in 2 to 10 committees for national professional engineering societies, involving such diverse activities as evaluating revisions in building and material codes, peer review of proposed environmental and health regulations, and development of national research programs. Examples include the American Society for Testing Materials (ASTM), the American National Standards Institute (ANSI) code-evaluation committees, and specialty committees for ASCE, IESNA, ASHRAE, WEF, and AWWA. Faculty members chair sessions at national and international technical conferences and have themselves been conference directors. Many faculty members volunteer their professional expertise to community boards and public groups associated with Colorado municipalities and state agencies. All these activities regularly bring faculty in contact with their practicing colleagues in Civil and Architectural Engineering. Details of these activities are in the faculty resumes in Appendix B.

D. Professional Development

Support for excellent teaching in Civil Engineering is strong. Typically teaching is at least 40% of a professor's activities, and also 40% of annual evaluation of merit assessment used for raises, and is of equal importance as research in promotion and tenure decisions. The nominal teaching load for research-active faculty in Civil Engineering is three semester courses per year, including both graduate and undergraduate classes, which is consistent with other departments in the College of Engineering and Applied Science. Faculty members are encouraged to participate in programs to develop their teaching. Many take advantage of support to participate in workshops on engineering curriculum development and teaching methods sponsored by the NSF and professional societies.

The college supports the professional development of faculty through the Faculty Excellence Program (see http://www.colorado.edu/engineering-facultystaff/awards-incentives/college-awards/faculty-excellence-program), which provides a number of financial support opportunities. This program includes:

- **Dean's Faculty Fellowships -** Selected faculty members are given one semester off from teaching a course, to focus on a major initiative in research and scholarly work or development of substantial educational materials or initiatives
- **Dean's Seed Funds for Novel Ideas -** Discretionary funds up to $10,000 provide seed support for new ideas, and are matched 1:1 by the department or program
- **Dean's Performance Awards -** $5,000 awards are given for top performance in categories such as research, teaching, professional progress, and overall performance of junior faculty, based on the annual performance evaluations for the prior calendar year
- **Matching funds** for research grants, laboratory renovation funds, and travel to funding agencies
- **Sabbatical Supplement Program -** This program offers an additional 20% of the academic-year salary to faculty members taking full-year sabbaticals, on top of the normal 50% of the academic-year salary that they receive on sabbatical. The department then retains the remaining 30% of the academic-year salary, and the faculty member is responsible for raising (or forgoing) 30% of her or his salary. In addition, the Dean will provide $4000 in discretionary funds for research, travel, etc. to each faculty member who successfully applies for this program.

The Department encourages professional development through attendance of conferences and workshops. Data are collected on faculty attendance of these events through the annual reporting and evaluation process. If faculty members are not participating in these events, it is noted by the chair. New faculty members have significant start-up packages with moneys designated for travel and professional development. Senior faculty members typically raise their own funds for travel to these events, but they can also make request of the Department or College on a case-by-case basis.

The College provides overarching guidelines for faculty mentoring. The College holds a new faculty orientation program at the start of the academic year. The Dean delivers a mentoring workshop at orientation, and new faculty and their mentors are invited to attend. Assignment of faculty mentors for new faculty is tracked by the Chair and the Dean. In addition, the former

Dean has written a document on mentoring for faculty, Tips for Faculty Mentoring (see http://www.colorado.edu/engineering-facultystaff/tips-faculty-mentoring).

The University of Colorado Boulder has a campus-wide Faculty Teaching Excellence Program (FTEP; http://www.colorado.edu/ftep) to help faculty develop new teaching and learning methods. Civil
Engineering faculty have served on FTEP panels to discuss educational innovations and participated in FTEP workshops on special topics such as using the Internet for teaching. FTEP also maintains a classroom visitation program to give teachers feedback and assistance in improving teaching methods for individual courses. Two CEAE faculty have recently participated in the ASCE ExCEEd teaching workshops.

Historically, CEAE faculty have received teaching awards from the College and national awards from ASEE (Young Faculty Award), the Association of Environmental Engineering and Science Professors (Outstanding Teaching), and the Society of Women Engineers (Distinguished Engineering Educator). Five faculty (Crimaldi, Hernandez, McCartney, Neupauer, Rajaram) have received NSF's prestigious Early Career Development (CAREER) award, which is partially based on the awardee's education plan.

Faculty have developed significant external funding for educational innovations, including NSF education grants to develop a unique teaching flume for fluid mechanics and hydraulics courses, a laboratory geotechnical centrifuge for soil mechanics laboratory projects, and planning for curriculum in service and outreach learning in an initiative called Engineering for Developing Communities. Private industry funding has been obtained to support development of a unique design experience in lighting engineering. In addition to the significant impact of these activities on Civil and Architectural Engineering students' education at the University of Colorado Boulder, publications in journals and presentations at ASEE and other conferences have contributed to new educational efforts at other universities.

For newly hired faculty, the College has a New Faculty Program, which focuses on mentoring and supporting new tenure-track faculty during their first few years.

In addition to teaching-related professional development, most CEAE faculty also routinely attend professional conferences where they present their research findings and learn about the latest developments in their area. Travel to these conferences is most often supported directly from the same grants that fund the research. For example, NSF requires dissemination of research results, and therefore funding to attend a conference to present the results is expected and normal.

E. Authority and Responsibility of Faculty

CEAE Department

The specific CVEN degree requirements are controlled fully by the CEAE faculty and senior instructors, within the constraints of the College of Engineering and Applied Science. All changes to required courses in the curriculum must be voted on by the CEAE faculty as a whole. All changes to the program educational objectives and student outcomes are also voted on by the faculty as a whole. Changes are passed if approved by a simple majority of the faculty present at the meeting, if a quorum is present (half plus one of the voting members of the Department). Voting members of the department include those with a full-time University of Colorado appointment in the ranks of Instructor, Senior Instructor, Assistant Professor, Associate Professor, and Professor; Research Assistant Professor, Research Associate Professor and Research Professor. Instructors must have held the position for two years.

The CEAE faculty set up the JEC (Joint Evaluation Committee) process for on-going review of program objectives, student outcomes, and curriculum. Each JEC is aligned with one or two of the six CEAE faculty groups, and at least one JEC meets every year to evaluate the civil and/or architectural engineering programs. One or more faculty serve on each JEC. Two or more faculty are involved in writing the self-study report that is provided to the JEC in advance of its meeting. The departmental Assessment Coordinator provides assessment data for the self-study. After the JEC submits its report of recommendations, the faculty in the reviewed sub-discipline area(s) meet to discuss the recommendations and respond. The responses are then passed to the curriculum committee in the Department, which discusses any recommended changes at the curriculum-level. The curriculum committee is composed of faculty representatives from each of the six groups, and an additional representative from the Engineering for Developing Communities (EDC) program. The curriculum committee reviews assessment data on the program, evaluations by the JEC, and reviews curriculum elements. It can approve content changes within courses, and recommend curriculum changes to the faculty.

Assignments to teach specific courses are generally determined by recommendations to the department chair based on consensus within each CEAE sub-discipline group. These course assignments consider instructor interest and expertise, and student feedback from FCQs.

A representative from civil engineering sits on the CEAS Undergraduate Education Council. This individual is appointed by the Chair of CEAE and has been a member of the curriculum committee; for many years this representative was also the CEAE Assessment Coordinator. The Undergraduate Education Council is chaired by the Associate Dean for Education. Voting members include faculty representatives from each degree program, the Assistant Dean for Students, the Associate Dean for Education, and those members granted voting status by the Associate Dean for Education. Staff representatives from each degree granting program, the Assistant Dean for Students, and the directors of the programs and services for student support and learning also participate on the committee. The Undergraduate Education Council is responsible for developing and coordinating undergraduate educational initiatives as described in the College's Strategic Plan and such other activities related to undergraduate education within the College as may be brought before the committee. Additional faculty may also serve on sub-committees that review specific service-level courses and other task forces (such as the first-year task force convened by Assoc. Dean Argrow in 2010).

The CEAE faculty are also represented on the CEAS assessment committee. The purpose of this committee is to consider/develop ongoing assessment measures used at the college and to act in an advisory capacity to the Director of Assessment and Accreditation (Beth Myers) for surveys that are administered by the Dean's office on behalf of the college's departments and programs. These surveys include the graduating senior survey, first-year student survey, summer internship survey, alumni survey, and employer survey. The CEAE Assessment Coordinator represents CEAE on this committee.

College of Engineering and Applied Science

The following is copied from the College Rules:
Approved: February 8, 2017
The Faculty. The members of the faculty shall consist of all Professors, Associate Professors, Assistant Professors, Teaching Professors, Scholars in Residence, Senior Instructors, Instructors, Research Professors, Research Associate Professors, and Research Assistant Professors in the College of Engineering and Applied Science on the Boulder campus. The Dean may also appoint members to one-year renewable terms from departments outside the College involved in degree granting programs such as Engineering Physics and Applied Mathematics. These additional members may be recommended for membership at the start of each academic year by their respective department chairs. Other additional members from outside the College may be appointed by the Dean for one-year renewable terms.

- **Voting Members**. The voting membership of the faculty shall consist of all Professors, Associate Professors, Assistant Professors, Research Professors, Research Associate Professors, Research Assistant Professors, Teaching Professors, Scholars in Residence, Senior Instructors, and full-time Instructors in the College of Engineering and Applied Science, plus any additional members appointed by the Dean. Faculty with such titles as adjoint, adjunct, visiting, lecturer, research associate, etc., are not voting members of the College but may be voting members of a department (or program) based on the rules of that unit.
- **Powers**. The college faculty shall collaborate with the Dean in the governance of the College of Engineering and Applied Science in all matters that concern only the college (in accordance with the Laws of the Regents, Article 4.A.5). In particular, through shared governance with the administration, the faculty shall have principal responsibility for academic and scholastic policy and ethics, and the faculty shall act jointly with the administration in areas of faculty appointment and review, regulation of student conduct and activities, budgeting review and resource recommendations, selection of academic administrators, determination of candidates for degree, and other policies concerning the general academic welfare of the College (in accordance with the Laws of the Regents, Article 5.E.5).
- **Secretary**. A Secretary shall be appointed by the Dean, to record any decisions and votes.
- **Faculty Meetings**. Faculty meetings shall be held at least once during each of the fall and spring semesters. Special meetings may be called by the dean or shall be called by the dean upon the written request of five members of the faculty. Twenty-four hours' notice of a special meeting will be given. The members present at any regular or special meeting shall constitute a quorum.

Dean of the College of Engineering and Applied Science. The dean of the college shall be its administrative head. The dean shall be responsible for the enforcement of admission requirements and for the general efficiency of the college and its departments and programs, and has overall responsibility for budgetary planning and allocation of funds, space and other resources, faculty assignments and work loads, recommendations on personnel actions, planning, accountability and reporting (in accordance with the Laws of the Regents Article 4.A.2). The dean shall enforce rules and regulations of the college. The dean shall confer with the department chairs about departmental needs. The dean shall make regular reports to the provost of the Boulder campus, and to the faculty of the college.

The Dean of the College of Engineering and Applied Science reports to the Provost. The Provost leads the Division of Academic Affairs at the University of Colorado Boulder. The Division of Academic Affairs is responsible for administering the academic programs and policies of the Boulder campus, and for providing intellectual leadership for excellence in teaching, scholarship, and creative work. The division recruits faculty, deans, and other academic leaders, and allocates resources to ensure high-quality teaching, research and creative work, and service. The Provost reports to the Chancellor, who in turn reports to the President of the University of Colorado.

Table 6-1. Faculty Qualifications

Civil Engineering

Faculty Name	Highest Degree Earned- Field and Year	Rank [1]	Type of Academic Appointment[2] T, TT, NTT	FT or PT[3]	Years of Experience			Professional Registration/ Certification	Level of Activity[4] H=high, M, L= low		
					Govt./Ind. Practice	Teaching	This Institution		Professional Organizations	Professional Development	Consulting/summer work in industry
Amadei, Bernard	PhD Civil Engineering, 1982	P	T	FT	1	35	29	PE [Europe]	H	H	M
Balaji, Rajagopalan	PhD Stochastic Hydrology & Water Resources, 1995	P	T	FT	0	20	17		H	H	L
Bielefeldt, Angela	PhD Civil Engineering, 1996	P	T	FT	1	21	21	PE [CO]	H	H	L
Chinowsky, Paul	PhD Civil Engineering, 1991	P	T	FT	3	23	15		H	H	M
Cook, Sherri	PhD Environmental Engineering, 2014	AST	TT	FT	0	2	2		M	M	L
Corotis, Ross	PhD Civil Engineering, 1971	P	T	FT	1	46	23	PE [CO,IL,MD]	H	H	M
Corwin, Chris	PhD Civil Engineering, 2010	I	NTT	FT	13	3	3	PE [CO]	L	M	M
Crimaldi, John	PhD Civil & Environm Engrg, 1998	P	T	FT	4	18	18		L	M	L
Dashti, Shideh	PhD Geoengineering, 2009	AST	TT	FT	0	6	6		L	M	L
Goodrum, Paul	PhD Civil Engineering, 2001	P	T	FT	3	16	5	PE [KY]	H	L	L
Gooseff, Michael	PhD Civil Engineering, 2001	ASC	T	FT	3	15	2		H	M	L
Hallowell, Matthew	PhD Construction Eng & Mgmt, 2008	ASC	T	FT	5	9	9		H	M	L
Hearn, George	DES Civil Engineering 1989	ASC	T	FT	10	28	28	PE [CO,NY]	M	L	M
Hernandez, Mark	PhD Environmental Engrg, 1994	P	T	FT	8	22	22	PE [CA]	H	M	L
Hubler, Mija	PhD Civil & Environ Engineering, 2013	AST	TT	FT	0	2	2		M	M	L
Javernick-Will, Amy	PhD Civil Engineering, 2009	ASC	T	FT	7	7	7		H	M	L
Kasprzyk, Joseph	PhD Civil Engineering, 2013	AST	TT	FT	1	5	5		M	M	L
Liel, Abbie	PhD Civil & Env. Engineering, 2008	ASC	T	FT	0	9	9	PE [CA]	M	H	M

Linden, Karl	PhD Civil & Environm Engrg, 1997	P	T	FT	1	22	12		M	H	M
Livneh, Ben	PhD Civil Engineering, 2012	AST	TT	FT	2	5	5		L	M	L
McKnight, Diane	PhD Environmental Engrg, 1979	P	T	FT	17	21	21		H	H	L
Molenaar, Keith	PhD Civil Engineering, 1997	P	T	FT	7	20	18		H	H	M
Montoya, Lupita	PhD Civil & Env. Engineering, 1999	AST	TT	FT	1	14	7		M	H	L
Morris, Matthew	MS Civil Engineering, 2002	I	NTT	FT	14	8	5	PE [CO]	M	L	M
Neupauer, Roseanna	PhD Hydrology, 2000	ASC	T	FT	0	17	12	PE[VA, NM]	H	H	L
Pak, Ronald	PhD Applied Mechanics, 1985	P	T	FT	1	32	32		H	H	L
Pfeffer, William (Tad)	PhD Geophysics, 1987	P	T	FT	9	29	29		H	H	L
Pourahmadian, Fatemah	PhD Civil Engineering, 2016	AST	TT	FT	0.5	0.5	0.5		L	L	L
Rajaram, Harihar	ScD Civil Engineering, 1991	P	T	FT	0	18	18		L	H	L
Regueiro, Richard	PhD Civil & Environm Engrg, 1998	ASC	T	FT	7	12	12		M	H	L
Ren, Zhiyong (Jason)	PhD Civil & Environ Engineering, 2008	ASC	T	FT	2	9	4		H	M	L
Rosario-Ortiz, Fernando	D.Env. Environ Science & Eng, 2006	ASC	T	FT	4	9	9		H	H	M
Ryan, Joseph	PhD Civil & Environm Engrg, 1992	P	T	FT	3	24	24		M	H	M
Saouma, Victor	PhD Civil Engineering, 1980	P	T	FT	0	33	33		M	M	L
Sideris, Petros	PhD Civil Engineering, 2012	AST	TT	FT	0	5	4	PE[G]FE [MI]	H	M	L
Silverstein, JoAnn	PhD Civil Engineering, 1982	P	T	FT	2	35	35	PE [CO]	H	M	L
Song, Jeong-Hoon	PhD Theoretical Appl Mechanics, 2008	AST	TT	FT	0	6.5	3		H	L	L
Summers, R. Scott	PhD Environmental Eng & Sci, 1986	P	T	FT	2	29	18		M	H	M
Walker, Mike	PhD Chemical Engineering, 2012	I	NTT	FT	4	3	3		M	H	L
Xi, Yunping	PhD Structural Engineering, 1991	P	T	FT	3	21	20		M	H	L
Zhang, Yida	PhD Civil & Environ Engineering, 2016	AST	TT	FT	0	1	1		L	L	L
Znidarcic, Dobroslav	PhD Civil Engineering, 1982	P	T	FT	0	35	31		L	L	L
Building Systems Faculty											
Beamer, C. Walter IV	PhD Civil Engineering, 2005	I	NTT	FT	10	5	5		L	M	M
Henze, Gregor	PhD Civil Engineering, 1995	P	T	FT	4	18	9	PE [NEB]	M	L	M
Krarti, Moncef	PhD Civil Engineering, 1987	P	T	FT	3	26	26	PE [CO]	H	H	M
Srubar, Wil V.	PhD Civil Engineering, 2013	AST	TT	FT	1.5	4	4		M	M	L
Vasconez, Sandra	MS Lighting 2000; MA Art Hist. 2005	I	NTT	FT	14	10	10		L	L	L
Zhai, Zhiqiang	PhD Building Technology, 2003	P	T	FT	2	14	14		H	H	M

Instructions: Complete table for each member of the faculty in the program. Add additional rows or use additional sheets if necessary. Updated information is to be provided at the time of the visit.

1. Code: P = Professor ASC = Associate Professor AST = Assistant Professor I = Instructor A = Adjunct O = Other
2. Code: TT = Tenure Track T = Tenured NTT = Non Tenure Track
3. At the institution
4. The level of activity, high (H), medium (M) or low (L), should reflect an average over the year prior to the visit plus the two previous years.

Table 6-2. Faculty Workload Summary

Civil Engineering

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Amadei, Bernard	FT	CVEN 3698 Engineering Geology, 3 cr, F 2016 CVEN 4/5837 Sp Tpc – Syst App Global Engrg, 3 cr, S 17 CVEN 5929 Sustainable Community Dev 2, 3 cr, S 2017 CVEN 5939 SCD Practicum, 3 cr, S 2017	25	40	35	95
Balaji, Rajagopalan, Department Chair	FT	CVEN 6393 Water Resources Seminar, 1 cr, F/S 2016/17 CVEN 6833 Advanced Data Analysis, 3 cr, F 2016 CVEN 5454 Statistical Methods for Nat/Eng Sys, 3 cr, S 17	40	40	20	60
Bielefeldt, Angela	FT	AREN 1316 Intro to Arch. Eng., 2 cr, F 2016 CVEN 1317 Intro to Civil & Env Eng., 2 cr, F 2016 CVEN 4897 Prof Issues in Civil Eng, 2 cr, F 2016 SUST 2800 Sp Tpc: Intro Sust, 1 cr, F 2016	34	33	33	60
Chinowsky, Paul	FT	*Admin Role – Associate Vice Provost Student Success*	15	25	60	90
Cook, Sherri	FT	CVEN 5534 Wastewater Treatment, 3 cr, F 2016 CVEN 5834 Sp Tpc – Environm Sustainability, 3 cr, F 2016 CVEN 4834 Sp Tpc – Sustainability Princip Eng, 3 cr, S 17	40	40	20	5
Corotis, Ross	FT	Fall SABBATICAL CVEN 5565 Life-cycle Engineering, 3 cr, S 2017	25	50	25	60
Corwin, Chris	FT	CVEN 3414 Fundls Environm Eng, 3 cr, F/S 2016/17 CV/EVEN 4464 Environm Engrg Processes, 3 cr, F 2016 CVEN 3424 Water/WW treatment, 3 cr, S 2017 CV/EV4434 Env Engrg Design, 4 cr, S 2017	80	0	20	25
Crimaldi, John	FT	CVEN 5313 Environm Fluid Mechanics, 3 cr, F 2016 CVEN 3313 Fluid Mechanics, 3 cr, S 2017	25	50	25	95
Dashti, Shideh	FT	CVEN 4/5728 Foundation Engineering, 3 cr, F 2016 CVEN 5818 Geotech Earthquake Engrg, 3 cr, S 2017	40	40	20	90
Goodrum, Paul	FT	CVEN 5286 Design Construction Operations, 3 cr, F 2016 CVEN 3256 Construction Equipment & Mths, 3 cr, S 2017	40	40	20	50

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
		CVEN 5836 Sp Tpc – Discrete Event & BIM, 3 cr, S 2017				
Gooseff, Michael	FT	CVEN 5333 Physical Hydrol/Hydroclimatol, 3 cr, F 2016 CVEN 5833 Sp Tc – Init. Academic Career, 1 cr, F 2016 CVEN 4/5833 Sp Tpc – Open Channel Hydraulics, 3 c, S 17 CVEN 5833 Sp Tpc – Surface Water Qual Model, 3 cr, S 17	40	40	20	90
Hallowell, Matthew	FT	CVEN 3256 Construction Equipment & Mthds, 3 cr, F 2016 CVEN 5226 Quality and Safety, 3 cr, F 2016 CVEN 3246 Introduction to Construction, 3 cr, S 2017	25	60	15	50
Hearn, George	FT	CVEN 4555 Reinforced concrete Design, 3 cr, F 2016 CVEN 5575 Advanced Steel Design, 3 cr, F 2016 CVEN 4545 Steel Design, 3 cr, S 2017	53	27	20	50
Hernandez, Mark	FT	AREN 2110 Thermodynamics, 3 cr, F 2016 MEDICAL LEAVE SPRING 2017	25	60	15	20
Hubler, Mija	FT	CVEN 3161 Mechanics of Materials 1, 3 cr, F 2016 *Family Leave spring 2017*	40	40	20	60
Javernick-Will, Amy	FT	SABBATICAL – full academic year	25	60	15	50
Kasprzyk, Joseph	FT	CVEN 5423 Water Resources Engrg, 3 cr, F 2016 CVEN 4333 Engineering Hydrology, 3 cr, S 2017 CVEN 5393 Water Resources Develop/Mgmt, 3 cr, S 2017	40	40	20	45
Liel, Abbie	FT	CVEN 4/5525 Matrix Structural Analysis, 3 cr, F 2016 CVEN 5835 Sp Tpc – Risk Landsc Ind Seism, 3 cr, F 2016 CVEN 3227 Probability Statistics and Decision, 3 cr, S 17	40	40	20	70
Linden, Karl	FT	FALL SABBATICAL CV/EVEN 4/5834 Sp Tpc – WASH, 3 cr, S 2017	20	60	20	20
Livneh, Ben	FT	CVEN 4333 Engineering Hydrology, 3 cr, F 2016	25	60	15	90
McKnight, Diane	FT	*On loan to NSF for full academic year*	10	20	70	10
Molenaar, Keith	FT	AREN 4056 Project Management 1, 3 cr, F 2016 *CEAS Associate Dean for Graduate Programs*	20	30	50	50
Montoya, Lupita	FT	CVEN 4/5554 Fundamentals of Air Quality, 3 cr, F 2016	40	40	20	30

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
		AREN 2110 Thermodynamics, 3 cr, S 2017 COEN 1410 Sust Community Design, 3 cr, S 2017				
Morris, Matthew	FT	AREN 2050 Building Materials and Systems, 3 cr, F 2016 CVEN 3246 Introduction to Construction, 3 cr, F 2016 CVEN 5836 Sp Tpc – CEM Fundamentals, 3 cr, F 2016 AREN 4606 Project Management 2, 3, S 2017 CVEN 4899 Civil Engrg Senior Project Design, 4, S 2017	80	0	20	45
Neupauer, Roseanna	FT	CVEN 3323 Hydraulic Engineering, 3 cr, F 2016 CVEN 4/5353 Groundwater Engineering, 3 cr, F 2016 CVEN 4/5383 Groundwater Modeling, 3 cr, S 2017	40	40	20	75
Pak, Ronald	FT	CVEN 5798 Dynamics of Soils/Foundations, 3 cr, F 2016 CVEN 3708 Geotechnical Engineering 1, 3 cr, S 2017 CVEN 5131 Continuum Mechanics & Elasticity, 3 cr, S 17	40	40	20	80
Pfeffer, William (Tad)	FT	FALL SABBATICAL CVEN 2012 Introduction to Geomatics, 3, S 2017	25	60	15	70
Pourahmadian, Fatemah	FT	STARTED JANUARY 2017 CVEN5831 Sp Tpc: Wave-Based Methods&Appl, 3, S2017	40	40	20	95
Rajaram, Harihar	FT	CVEN 5537 Numerical Methods in Civil Eng, 3 cr, F 2016 CVEN 6383 Flow & Transport Porous Media, 3 cr, F 2016 SPRING 2017 ON SABBATICAL	40	40	20	90
Regueiro, Richard	FT	CVEN 3708 Geotechnical Engineering 1, 3 cr, F 2016 CVEN 7511 Comp Finite Inelast Multiph Mech, 3 cr, F2016 CVEN 5788 Computational Modeling in Geotech, 3 cr, S17	40	40	20	80
Ren, Zhiyong (Jason)	FT	CVEN 5614 Bioenergy & Bioresource Recov, 3 cr, F 2016 CVEN 4/5834 Environmental Microbiology, 3 cr, S 2017 CVEN 5834 Sp Tpc – Emerg Tech: Microb Elctchm, 3, S17	40	40	20	5
Rosario-Ortiz, Fernando	FT	CVEN 4404 Water Chemistry, 3 cr, F 2016 CVEN 4414 Water Chemistry Lab, 1 cr, F 2016 CVEN 5424 Environm Organic Chemistry, 3 cr, S 2017	25	60	15	5

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Ryan, Joseph	FT	EVEN 4100 Environml Sampling & Analysis, 3 cr, F 2016 CVEN 5404 Environm Engrg Chemistry, 3 cr, F 2016 CV/EVEN 4424 Environm Organic Chemistry, 3 cr, S 2017	40	40	20	5
Saouma, Victor	FT	CVEN 7161 Fracture Mechanics, 3 cr, S 2017 CVEN 3525 Structural Analysis, 3 cr, S 2017	25	60	15	80
Sideris, Petros	FT	CVEN 2121 Analytical Mechanics 1, 3 cr, F 2016 CVEN 5111 Intro Structural Dynamics, 3 cr, F 2016 CVEN 5835 Sp Tpc – Exper Methods Str Eng, 3 cr, S 2017	40	40	20	80
Silverstein, JoAnn	FT	CVEN 4/5147 Civil Engineering Systems, 3 cr, F 2016 CVEN 5834 Sp Tpc – Small System W/WW Tmt, 3 cr, S 17	30	40	30	50
Song, Jeong-Hoon	FT	CVEN 4/5511 Finite Element Analysis, 3 cr, F 2016 CVEN 3111 Dynamics, 3 cr, S 2017	40	40	20	70
Summers, R. Scott	FT	EVEN 1000 Introduction to Environm. Engrg, 1 cr, F 2016 CVEN 5464 Environm Engrg Processes, 3 cr, F 2016 CVEN 5524 Water Treatment, 3 cr, S 2017	25	40	35	5
Walker, Mike	FT	CV/EVEN 4/5434 Environmental Engrg Design, 4 cr, S17 EVEN 4830 Sp Tpc – Env Eng Process Model, 3 cr, F 2016 MCEN 3032 Thermodynamics 2, 3 cr, F/S 2016/17	80	0	20	10
Xi, Yunping	FT	CVEN 4/5161 Adv Mechanics of Materials 1, 3 cr, F 2016 CVEN 4535 Construction Materials, 1 or 3 cr, F 2016 CVEN 3161 Mechanics of Materials 1, 3 cr, S 2017	40	40	20	70
Zhang, Yida	FT	CVEN 5708 Soil Mechanics, 3 cr, F 2016 CVEN 7718 Engineering Properties of Soils, 3 cr, S 2017	40	40	20	90
Znidarcic, Dobroslav	FT	CVEN3718 Geotechnical Engineering 2, 3 cr, S 2017 CVEN 5748 Design of Earth Structures, 3 cr, S 2017	40	40	20	80
Building Systems						
Beamer, C. Walter IV	FT	AREN 3540 Illumination 1, 3 cr, F 2016 AREN 4580/5830 Daylighting, 3 cr, F 2016 CVEN 5830 Sp Tpc – Bldg Energy Sys, 1 of 3 cr, F 2016	55	20	25	5

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
		[resigned from CU effective January 2017]				
Henze, Gregor	FT	AREN 4/5890 Sustainable Building Design, 3 cr, F 2016 AREN 4/5010 HVAC System Modeling Control, 3 cr, S 17 AREN 4/5110 HVAC Design, 3 cr, S 2017	40	40	20	5
Krarti, Moncef	FT	AREN 4570/5830 Electrical Systems, 3 cr, F 2016 CVEN 5830 Sp Tpc – Bldg Energy Systems, 3 cr, F 2016 AREN 5020 Building Energy Audits, 3 cr, S 2017	25	60	15	5
Srubar, Wil V.	FT	AREN 4/5830 Sp Tpc – Sustain. Matls & Str, 3 cr, F 2016 AREN 4/5830 Sp Tpc – Forensic Engineering, 3 cr, F 2016 CVEN 4565 Timber Design, 3 cr, S 2017	40	40	20	30
Vasconez, Sandra	FT	AREN 4530 Advanced Lighting Design, 3 cr, F 2016 AREN 4830 Sp Tpc – Arch. Lighting Design, 3 cr, F 2016 AREN 4550 Illimunation II, 3 cr, S 2017 CVEN 5830 Sp Tpc – Illumination II, 3 cr, S 2017	70	0	30	5
Zhai, Zhiqiang	FT	AREN 3010 Mechanical Sys for Buildings, 3 cr, F 2016 CVEN 5830 Sp Tpc – Bldg Energy Systems, 3 cr, F 2016 AREN 2120 Fluid Mechanics & Heat Transfer, 3 cr, S 2017	40	40	20	5

1. FT = Full Time Faculty or PT = Part Time Faculty, at the institution
2. For the academic year for which the Self-Study Report is being prepared.
3. Program activity distribution should be in percent of effort in the program and should total 100%.
4. Indicate sabbatical leave, etc., under "Other."
5. Out of the total time employed at the institution. Most faculty are less than 100% to the Civil Engineering program due to time devoted to Architectural Engineering (AREN) or Environmental Engineering (EVEN) students via course instruction and/or advising.

CRITERION 7. FACILITIES

A. Offices, Classrooms and Laboratories

The CEAE department is housed primarily in the Engineering Center, where the main office, undergraduate advisor, and most faculty offices are located. The majority of the environmental and water resources faculty offices and research space is housed in the Sustainability, Energy and Environment Complex (SEEC) on East Campus. Office hours are held by Teaching Assistants primarily in offices in the Engineering Center.

Most of the undergraduate civil engineering classes are offered in centrally-scheduled classrooms in the Engineering Center and the Fleming Building. Working with the campus OIT organization, the college ensures that the open computer labs in the engineering center are configured with software tools needed by engineering students.

The CEAE program has three classrooms for which it controls scheduling: ECCE 1B41 (up to 49 students), ECCE 1B43 (up to 25 students), ECCE 1B52A (up to 20 students). Undergraduate courses and office hours are held in ECCE 1B41 and ECCE 1B43. Only office hours have been held in ECCE 1B52A (which is a classroom space within the structural engineering laboratory). ECCE 1B41 was recently extensively renovated (Spring 2016) to allow teaching simultaneously a local group of students and off-site students. This classroom includes state of the art A/V equipment including two 80” monitors and two 6’ erasable black boards on the east wall and a 50” monitor on the west wall.

The CEAE department on behalf of the CVEN program maintains specialized teaching laboratories for undergraduate courses in mechanics and structural engineering, geotechnical engineering, fluid mechanics, hydraulics, and water resources engineering. The laboratories associated with building mechanical and lighting systems are primarily used by architectural engineering students, and there is also a laboratory for environmental engineering. Undergraduate teaching laboratories feature state-of-the-art equipment such as a novel small-scale geotechnical centrifuge, computer-controlled material testing equipment, hydraulic benches and flumes, instruments for advanced water quality analyses such as a gas chromatograph and water treatment process simulation such as activated carbon adsorption columns. In addition, laboratories have enough small instruments and supplies dedicated to courses with laboratory components to permit simultaneous hands-on laboratory experiments and independent data collection by 4-6 student teams working simultaneously in both the Civil Engineering laboratories and Integrated Teaching and Learning Laboratory (a building adjacent and connected to the Engineering Center).

a) Geotechnical engineering laboratory

Laboratory experiments and demonstrations make up approximately 30% of the required junior-level CVEN 3708 Geotechnical Engineering I course, and also about 30% of the geotechnical proficiency course CVEN 3178 Geotechnical Engineering 2. There are two laboratories dedicated to student use in geotechnical engineering courses, both located in the Engineering Center. In Geotechnical Engineering I, student groups learn soil classification methods (sieve and hydrometer) and other methods for determining soil properties (Atterberg limits, soil compaction, permeability and consolidation). More sophisticated equipment is used in Geotechnical Engineering II, including direct shear apparatus and a unique geotechnical centrifuge equipped with in-flight camera and automated data acquisition so that students can collect and interpret real-time data on slope failure. See information at: http://www.colorado.edu/ceae/research/geotechnical-engineering-geomechanics/facilities. Student teams in Geotechnical Engineering II also conduct triaxial compression tests, direct shear tests, slope stability, retaining wall and soil bearing capacity experiments.

b) Water resources engineering laboratory

Approximately 25% of the work in the required fluid mechanics course (CVEN 3313) is laboratory experiments, all of which are carried out in the ITLL. Equipment includes hydraulic benches with water reservoirs, pumps, piping and flow measurement devices for student lab groups and a single flume that student groups can use sequentially or is used for demonstrations. The ITLL also has computer equipment and software (LabView) for data acquisition and analysis. Approximately 50% of the required course Hydraulic Engineering (CVEN 3323) consists of laboratory experiments, amounting to one three-hour lab session each week. The fluid mechanics and hydraulics laboratory is located in the Civil Engineering (CE) wing of the engineering center. The student groups in the CVEN 3323 laboratories have access to a dedicated teaching flume equipped with acoustic velocity instrumentation and a laser-based flow visualization system. http://bechtel.colorado.edu/~crimaldi/laboratory.html.

c) Structural engineering and materials laboratory

There are laboratory components in mechanics of materials I (CVEN 3161) and advanced mechanics of materials (CVEN 4161), and laboratory demonstrations and experiments are carried out both in the ITLL and in the structures laboratory in the CE wing of the Engineering Center. The Department has a site in the NSF-funded George E. Brown Jr., Network for Earthquake Engineering Systems, the Fast Hybrid Test Facility, which has enabled major equipment upgrades in the structures laboratory, which in turn will benefit undergraduate students in courses with demonstrations as well as opportunities for hands-on experiments. There are 110 kip and 1,000 kip Universal Testing machines with automated data acquisition, and facilities for fabrication of concrete and steel structural elements and sensors for testing (http://www.colorado.edu/ceae/research/structural-engineering-structural-mechanics/facilities).

d) Surveying-Geomatics laboratory

Plane Surveying (CVEN 2012) is taken by all students in Civil and Architectural Engineering. In 2004 the curriculum was broadened to incorporate GPS hardware and software and GIS software in a course that will be renamed Geomatics. Laboratory work, field measurements, and computer lab assignments comprise the majority of the course work by student teams. Sufficient surveying instruments are available for six student crews to work in the field simultaneously. These include traditional transits, theodolites and levels. Modern instruments used are EDM, total stations, and a digitized level. There are six PCs and a plotter to allow each student crew to download and analyze field data immediately. The lab also has bench space for minor repairs and adjustments to equipment. In addition, GPS and GIS software are available on the Bechtel Lab (see below) server for both in-class instruction and student projects.

The CEAE department maintains additional laboratories for environmental engineering, building systems, and lighting; but these laboratories are not used in courses required for CVEN students or typical electives for CVEN students.

The students rate the overall quality of the facilities on the graduating senior survey. The facilities are rated on a scale of 1 = poor, 2= marginal, 3=fair, 4=good, and 5=excellent. Results are summarized below. All ratings are 3 or higher, which is adequate. The weakest ratings are for classrooms and the lobby, over which the department has no control; fortunately, the engineering lobby is due to be completely renovated in Summer 2017.

Facilities Ratings on the Graduating Senior Survey (average of CVEN respondents)

Year	2015-2016	2014-2015	2013-2014	2012-2013	2011-2012
Department experimental labs	3.40	3.66	3.43	3.67	3.96
Classrooms	3.16	3.22	3.22	3.26	3.44
ITLL	4.19	4.37	4.13	4.12	4.35
Engineering library	3.65	3.79	3.73	3.88	3.96
Engineering lobby	3.00	3.02	3.40	3.36	3.73

B. Computing Resources

Campus-wide/Institutional Computing Resources

The majority of campus-wide computing resources are provided by the Office of Information Technology (OIT), which provides CU-Boulder with innovative, customer-focused IT support and core IT services. Under the leadership of the Office of the Associate Vice Chancellor for IT and CIO, OIT partners and collaborates with academic, research, and administrative units in order to create a robust, best-in-class IT environment.

Computing resources are provided by OIT as well as colleges, departments, institutes, centers, etc. OIT provides coordinated, centralized IT support as well as core IT services in areas such as academic technologies, communication technologies, enterprise IT services, infrastructure, Research Computing and IT security.

Networking

The University of Colorado Boulder has a robust, enterprise-level network that serves both wired and wireless Internet access to nearly every corner of the campus, as well as providing VPN opportunities for off-campus connections.

- Wired connectivity – 1 Gigabit/secs Ethernet, 13 distribution routers, 700 switches, servicing ~23,000 hardwire attached devices
- Wireless connectivity – 802.11a/b/g/n/ac, 85,000 registered wireless devices
- VPN connectivity
- Institutional network backbone – 10 Gigabit/sec Ethernet and multiple 10 Gigabit/sec Internet connectivity.

- ScienceDMZ – 80 GigaBit/sec core with no firewalls and 10 Gigabit/sec Internet connectivity managed jointly by Research Computing and OIT networking

Teaching and Learning Spaces

Students, faculty, and staff have access to a variety of OIT Technology Enhanced Learning Spaces. OIT maintains over 200 technology-equipped classrooms campus wide, which includes most (but not all) College of Engineering and Applied Science's classrooms. Each technology-equipped classroom and lecture hall contains at minimum a video display (LCD or Data Projector), audio reinforcement, and wireless networking capability. Classroom sizes range from 12 to 375 seats. Most classrooms on campus have an audience response system, CU iClicker. All OIT supported spaces have an assigned CU iClicker frequency posted.

Computer Labs

There are forty-two centrally-managed labs on campus. Eight of them are in Engineering buildings. The University maintains a three or four year hardware replacement schedule for most workstations. Software on the machines is upgraded every semester with new or updated versions of important Engineering software packages. The hours of availability and access vary according to the policies of individual buildings and departments. However, most Engineering labs are open 24 hr./day, 7days/week to students in the College of Engineering.

Engineering Labs

There are eight centrally-managed computer labs in the Engineering complex. These labs are configured with similar workstation hardware and software in all locations. Current configurations and software availability can be found on the OIT website: http://webdata.colorado.edu/labs/map/ (Click on individual labs to view loadsets.)

Open student engineering lab locations and resources include the following rooms: ECCE 141 (CADLab), ECCE 152 (Soils), ECCR 143 (APPM), ECCR 235, ECCR 239, ECCR 252, ECES 107, JCSB A205.

In addition to a much larger set of software available in Engineering labs, the following engineering-related software is also installed on many Open Student Engineering Labs

A variety of software compilers	LabView
Abaqus	Mathcad with Prime
Ansys	Mathematica
ArcGIS	MATLAB
AspenONE Suite	OriginPro
AutoCAD	R
EES (Engineering Equation Solver)	Revit
EQS	SAS
IDL	SolidWorks
JMP PRO	

Classrooms

OIT maintains Technology Enhanced Learning Spaces.

Smart Classrooms (S) – 0 to 155 seats.
These classrooms contain the features listed below:

- Digital image display, projection screen or video monitor
    - Laptop inputs could include VGA, HDMI and\or MiniDisplay
- Most rooms have DVD players
- Content audio reinforcement, wall or ceiling speakers
- UCB Wireless and UCB Guest wireless connectivity
- iClicker frequency assigned
    - Not all rooms are assigned a base station
- Manual writing surface such as chalkboard or dry erase board
- Student seat and table types vary greatly from room to room
    - Rooms with tables could be fixed or modular with modular chairs
    - Rooms without tables have student seats which could be fixed or modular style seating with armchair writing surfaces
- All rooms are supplied with an instructor table/lectern
    - This may range from a large lectern, small lectern, table-top lectern or a table
- AV room control (source routing) system
    - Button controllers
    - Remote handheld monitor control (only few LCD TV monitor rooms)

Large Lecture Halls (L) – Over 155 seats.
These classrooms contain the features listed below:
- ADA accessible lectern with height adjustment
- Digital image display, projection screen(s) or video monitor(s)
    - Laptop inputs could include VGA, HDMI and\or MiniDisplay
- Minimum of DVD players, some have Blu-Ray
- Content audio reinforcement
- Multiple wireless microphones for voice audio reinforcement
    - Minimum of one handheld and one lapel microphone
- Assisted listening technology for hard of hearing compliancy
    - Full-room T-coil hearing loop or
    - Individual listening receiver systems
- Document camera
- UCB Wireless and UCB Guest wireless connectivity
- iClicker frequency assigned
    - Not all rooms are assigned a base station
- Manual writing surface such as chalkboard or dry erase board
- Student seats are fixed with armchair writing surfaces
- Lecture capture features available by request
- Some rooms are equipped with software-based Video Conference capability through USB connection using a user supplied laptop
- Minimum of one pan/tilt/zoom video camera with multiple pre-set camera selections
- Audio Visual room control system
    - Interactive multiple video source routing touch panel (Crestron)

Distance Learning Spaces (D) – 10 to 100 seats.
These classrooms contain the features listed below:

- ADA accessible lectern with height adjustment
- Dedicated lectern Windows-based computer
- Multiple digital image displays, projection screens and/or video monitors
    - Primary lecture content
    - Secondary lecture content
    - Rear wall confidence LCD monitor
    - Laptop inputs include VGA, HDMI and MiniDisplay
- DVD player
- Content audio reinforcement
- Multiple wireless microphones for voice audio reinforcement
    - Minimum of one handheld and one lapel microphone
- Assisted listening technology for hard of hearing compliancy
    - Full-room T-coil hearing loop or
    - Individual listening receiver systems
- Document camera
- UCB Wireless and UCB Guest wireless connectivity
- iClicker frequency assigned
    - Not all rooms are assigned a base station
- Manual writing surfaces such as chalkboard, dry erase board and interactive LCD monitor
- Student seats are fixed or modular with fixed or modular tables or armchair writing surfaces
- Lecture capture features available by request
- Hardware-based Video Conference/Synchronous Participation capability through codec
- Multiple pan/tilt/zoom video cameras with multiple pre-set camera selections
- Audio Visual room control system
    - Interactive multiple video source routing touch panel (Crestron)
- Operator supported for distance education courses only
- Redundant lecture capture system
- WACOM annotation over content
- Audience microphones for recording purposes only
- Some rooms have stage lighting for recording
- USB connectivity for the dedicated PC and the Laptop input to allow annotation to either device from the WACOM or Touch LCD monitors where available

Computer Labs (Lab) – 6 to 50 seats.
These classrooms contain the features listed below:

- Some rooms are outfitted with **Smart Classroom (S)** technology
- PC or Macintosh computing devices with a single display

Additional Administrative Systems

University of Colorado professors participate in the Faculty Purchase Program, which provides them with $1,200 for a new computer every 4th year.

Additionally, administration of the campus is supported by a central portal (my.cu.edu), a learning management system (Desire2Learn), and various database software applications. This includes, but is not limited to: web presentation and content services through Google Apps for Education, course schedules, grades, billing information, employment listings, Registrar forms, announcements, news, and events, online file access, e-mail, calendaring, the college catalog, financial aid, online-registration, student academic records, and Faculty Report of Professional Activity (FRPA) information. Our library system uses technology that includes a digital catalog with 300 citation indexes, full-text databases, 23 academic, public and special libraries, 20 million books, journals DVDs, CDs, videos, and is linked to thousands of libraries across the world.

Academic Technologies

Besides ubiquitous Internet connectivity and laboratory space, students are provided with many other computing services and software. Students are offered two walk-in desktop support centers for software and hardware support. Teaching and learning technologies include Desire2Learn, CUClickers, Lynda.com, Google Apps for Education, Microsoft 365, and some Lecture Capture possibilities. Captioning guidelines and consultation are provided to all campus constituents while media captioning is provided to meet accommodation requests.

Faculty members using technologies in the classroom are supported by both dispatched and walk-in desktop support, robust phone and email support, and a team of Technology Learning Assistants who provide 1:1 support and workshops for teaching and learning technology use in the classroom.

Additionally, the College of Engineering and Applied Science is served along with the larger campus by the Academic Technology Design Team, a group consisting of media, universal, and learning designers, social media experts, and data analytics professionals. College leaders partner with the ATDT to define strategic and complex learning problems and pilot solutions through the creative application of new technologies. Three of the showcase campus projects were partnerships with the College of Engineering and Applied Science, including the launch of two Coursera engineering MOOCs (one from the Department of Computer Science), the ambitious redesign of Introduction to Engineering, and forward-looking flipped redesign of a senior/graduate level statistics course.

CEAE Department Computing Facilities

The CEAE Department has access to two large computing facilities for use by Civil and Architectural Engineering courses and individual students, the CAD laboratory (described above, ECCE 141), which is maintained by the Campus OIT, and the Bechtel laboratory (ECCE 157 and ECCE 161) which is controlled by the Department and maintained via a contract to OIT. The computers and peripheral hardware in the CAD lab are replaced approximately every three years. Both rooms have laser printers (color laser in Bechtel) and student print jobs are subsidized by the Department. All these computers are Auto-CAD workstations and contain general spreadsheet, word processing and Internet access software. The drawing class (AREN 1317) is taught in the CAD lab. The Bechtel lab contains professional-level software in classes, as well as general software, including those shown in the table below. Undergraduate required courses that periodically use the Bechtel lab include: CVEN 1317 Introduction to Civil Engineering, CVEN 3323 Hydraulic Engineering, CVEN 4897 Professional Issues in CE (for the practice FE exam); and electives such as CVEN 4511 Finite Element Analysis, 4383 Groundwater Modeling, CVEN 4525 Matrix Structural Analysis, and AREN 4606 Project Management 2.

Priority for both the CAD-Lab and Bechtel Lab computing facilities is undergraduate classroom use, with use by individual students and student teams from Civil and Architectural Engineering heavy during non-teaching hours. The Department has contracted with OIT to maintain the Bechtel Lab.

ECCE 157 houses the Bechtel Computer Aided Design Laboratory (West). This facility is accessible to CEAE students via card-swipes programmed to their Buff One ID cards, 24 hours/day, 7 days/week. The lab includes 29 Dell Precision T3610, Intel Xeon E5-1620 Quad-Core v2 Processor, 8GB RAM, 2GB NVIDIA Quadro K2000 Video Card, 900 GB SAS 10,000 RPM drive, laser scroll mouse, and Dell UltraSharp 24 Monitor U2412. The computers have the standard software applications as well as many specific to CEAE including: Abaqus CAE, ACI 318-08, AGi32-16.8, AnAqSimEDU, ArcGlobe 10.2, ArcMap 10.2, ArcScene 10.2, Aspen HYSYS V8.8, AutoCAD 2016, AutoCAD Civil 3D 2016, Revit 2016, BEopt 2.6, BioWin 5.0, Bluebeam Revu, Bridge Designer 2015 (2nd Edition), Climate Consultat 5.4, DEEPSOIL v. 6.1, DesignBuilder, DIALux 4.12, EES, EnergyPlus8.4, EPA SWMM 5.0, EPANET 2.0, eQUEST 3-64, F-Chart, FLOWNETz, GeoStudio 2007, GW Chart (MODFLOW GUI), HEC-HMS Hydrologic Modeling System, HEC-RAS River Analysis System , HYDRUS-1D 4.14, landgem-v302, McTrans HCS+ 5.2, MT3DMS 4.3 , On-Screen Takeoff 3, Palisade Decision Tools, Pertmaster v8, PHOENICS VR, Photopia, Simphony Processing Modflow, Project Management – Oracle Primavera, REMChlor, RiverWare 6.5, RT3Dv25full, SAP2000 12, SeismoSignal, SimaPro Multi user, Structural Moderler V8i (SELECTseries 1), Trane TRACE 700 v6.2 , TRNSYS 16, Visual MINTEQ 3.0, VisualDOE 4, @RISK 7, Evolver 7, PrecisionTree 7, StatTools 7.

ECCE 161 Bechtel Computer Aided Design Laboratory (East) includes 33 workstations that mirror those in Bechtel West. Access to the lab is identical to Bechtel West.

Example of specific software used primarily by the different sub-groups within civil engineering are listed in the table below.

Examples of software used primarily by different civil engineering groups

Type	Programs	Locations
Construction	Primavera, On-Screen Takeoff	Bechtel Lab
Environmental	BioWin, BioCHLOR, SimaPro,	Bechtel Lab
Geotechnical	PLAXIS, DEEPSOIL, SEEP_W, SIGMA_W, SLOPE_W	Bechtel Lab
Geomatics / surveying	Quicksurf; Horizon Solutions – Plane Surveying, GPS software; ARCVIEW 3.3 and ARCGIS 9.0	CAD lab Bechtel lab

Type	Programs	Locations
Structural Engineering	ALGOR, SAP90, SAP 2000 (nonlinear), SODA, FEAP, ABAQUS, Linear Stress and Vibrations	Bechtel lab
Water Resources	EPANET, HEC-HMS, HECRAS, SWMM, WATERCAD, STORMCAD, MODFLOW, IWR-MAIN, WEAP and CUP.	Bechtel lab
Miscellaneous	Bridge Designer (CVEN 1317); Math tools: Mathematica, MatLab, SPSS	Bechtel Lab All computing labs

On the graduating senior survey, CVEN students rate the quality of the computer facilities on a scale of 1 = poor, 2= marginal, 3=fair, 4=good, and 5=excellent. Results are summarized below. All ratings for both campus centrally controlled (OIT) computing facilities and departmental computing facilities were adequate, at 3.4 and higher.

Graduating Senior Survey Average Ratings for Computer Facilities

	2015-2016	2014-2015	2013-2014	2012-2013	2011-2012
OIT computer facilities	3.40	3.48	3.41	3.58	3.72
Department computer facilities	3.69	3.62	3.50	3.65	3.85

C. Guidance

The Department provides students with guidance on the use of the computing tools, resources, and labs discussed in this section via a variety of means. In courses where students will be using laboratory facilities (e.g. geotechnics, mechanics, water resources), the instructor and/or teaching assistants (TAs) describe the relevant equipment to students. Important health and safety requirements and precautions are described. Safe equipment use is monitored during the laboratory sessions by the TA and/or faculty. User guides and/or instructions for each laboratory and necessary equipment are provided to the students. The students work with the laboratory equipment during supervised laboratory times, with immediate access to teaching assistants and/or faculty to answer their questions.

The primary methods of guidance for use in the computing resources include leveraging University-wide OIT training resources, semester-length tooling courses, online and video documentation, extracurricular training sessions, and peer-tutoring. Many of the computer resources leveraged by the Department are provided by the OIT. OIT provides training and guidance for such resources to students directly via their website, walk-in support desk, and phone and email support center.

D. Maintenance and Upgrading of Facilities

CEAE Departmental Experimental Laboratories

The faculty who teach courses using the undergraduate teaching laboratories monitor the equipment used and generally perform basic maintenance. The department collects student fees, and the money is used to maintain, repair, and replace the laboratory equipment, when needed. The relevant course instructor simply informs the department chair of any needs, and makes the necessary purchases or contracts for needed service. Instructors can also request new equipment as they keep laboratory experiences up-to-date with current practice. Major equipment requirements are often cost-shared between the College (via a request for funding to the Engineering Excellence Fund) and the Department. One example of recent updates to equipment is the CVEN 2012 Introduction to Geomatics course, which purchased a variety of new equipment that was specified by Prof. Tad Pfeffer.

OIT Controlled Computing Facilities

The computer hardware in the centrally-managed computer labs are configured to meet the high-end demands of the software specific to engineering disciplines. The hardware is purchased with a 3-year warranty, and the machines are refreshed at the end of the three years to ensure that the labs stay current with the demands of new and updated software. Software are loaded to the machines at the beginning of each term. Microsoft security updates are applied weekly after-hours to ensure they do not impact the availability of the machines during classes or while students are using the machines. In addition, because these machines are used in multi-user environments, we ensure that changes made by previous users are not maintained across logins. This ensures a consistent and familiar environment for the students and faculty that use them. The machines are all configured with antivirus software to protect the students and other machines from viruses, and logins and application usage data is tracked to help us make better decisions about software licensing and machine availability.

E. Library Services

The Leonard Gemmill Engineering, Mathematics & Physics Library, opened in 1992, is an 18,000 square foot facility (http://www.colorado.edu/libraries/libraries/engineering-math-physics-library). In 2016, during fall semester approximately 242,945 user visits were recorded, and during spring semester approximately 227,600 user visits were recorded. The library is open 83 hours per week when fall and spring semesters are in session and 40 hours per week during the summer session. Additionally, it provides 24/7 access to a substantial electronic collection. Additionally, college students have access to collections in four other libraries on campus, as well as regional and world-wide interlibrary loan services free of charge.

Three paraprofessional and two professional librarians, as well as several trained student assistants, are available to answer reference questions in several modalities. Research help is available by dropping by the circulation desk or making an appointment with a subject specialist, as well as by telephone, email, and synchronous chat services. Typically, these services are fully staffed from eight to five pm, with chat service available into the evening hours. Further, librarians in the sciences department, which serves computers science, are available to provide in-class information literacy instruction, online tutorials, and workshops. They offer course-integrated instruction, designed around finding information resources for particular assignments or projects in a class, as well as workshop series known as Science Learner's Lunches, which focus on information literacy skills needed for lifelong learning, as well as technology skills.

The Gemmill Library spaces are designed to facilitate student success and academic engagement. The Gemmill provides 22 OIT-managed computers with a full range of office, design, and statistical-analysis software for students, faculty and staff, as well as several public computers with more limited software. Printers and two scanners are available, as well as a large screen designed to facilitate group work. Seven study rooms are available for group study; four are reservable in advance and three are available for drop in use. A library instruction room, Math 150, can accommodate up to 20 people for libraries classes, group study and student events. This room, with its large presentation screen and modular furniture, is available for student group study whenever it is not in use for library instruction or by affiliate events (which could include events or tutoring sponsored by the computer science department). The Gemmill strives to develop spaces that are flexible and promote student learning; the upper floor featuring movable furniture is available for collaborative work and discussion, while the lower floor is a quiet area for individual study.

The libraries continue efforts to provide access to important collections, particularly electronic collections and discovery platforms, as budgets remain tight. The Gemmill Library provides over 155,000 print monographs and 100,000 microform technical reports. Access to online materials includes bibliographic indexes, such as *Compendex* and *INSPEC* on the *Engineering Village* platform, as well as searchable full text providers, such as *IEEE Xplore* and *ACM Digital Library.* A comprehensive list of electronic tools and databases is available(http://libguides.colorado.edu/az.php?a=all) . These journals, and engineering and computer science handbooks and manuals from many publishers, are available 24 hours per day from any location via proxy access. Book purchase requests can be submitted to any member of the Library staff, or by using an online form (http://www.colorado.edu/libraries/services/suggest-library-purchase). The vast majority of monograph suggestions are purchased. Moreover, the libraries use a patron driven acquisition model that allows us to provide access to a wide variety of e-books, and instantly purchase those that our campus community uses.

The Gemmill Library is committed to building an evidence-based, user-centered library. Various assessments gathered by the Library (including an international benchmark survey known as *LibQUAL+*) over the last 10-12 years have led to several completed and planned changes. *LibQUAL+* feedback, for example, was used to instigate and guide the redesign of the libraries web sites. It also led to the provision of a proxy service for off-campus access in addition to the VPN. Other assessment data has led to the Library reconfiguring its space to provide flexible study areas. As journals shift to electronic access and bound journals were moved to an off-campus space with 24-hour turnaround scanning, this opened space for student study. We turned to students to discover how best to shape this new space: nearly every year, the Gemmill Library works with an upper-division technical writing and design course project team to assess space use, user needs, and more. This feedback is quickly turned around and applied to the library's spaces. Recent changes have included adding wheels to existing furniture, providing more whiteboards, and adding chalkboard walls, for example. We gather and respond to feedback from students but also attend to the larger institutional context. The Head of the Engineering Library sits on the College's Undergraduate and Graduate Education Councils and uses information gathered from those councils to help guide library decision-making, as well. In short, this library is envisioned as one where students can access information, information professionals, faculty, productivity tools, and one another in one facility; a place where ABET criteria regarding engineering tools and lifelong learning skills can be pursued.

F. Overall Comments on Facilities

All of the classrooms, offices, labs, equipment, and facilities that are housed within university buildings conform to standard fire, safety, building, and health codes.

The Environmental Health and Safety (EH&S) department at the University of Colorado at Boulder (http://www.colorado.edu/ehs) provides comprehensive environmental, health and safety services to minimize health and safety impacts to the campus and the greater Boulder community. EH&S accomplishes this through training, emergency planning, consultation and partnership with members of the campus community as well as with local, state and federal agencies. Environmental Health and Safety provides regular training programs for UCB faculty, staff and students. These classes are mandatory for those who handle, manage or come into contact with potentially hazardous materials. EH&S has a substance disposal service in which hazardous waste or expired chemicals are removed from laboratories and disposed of according to state and federal regulations, ensuring a safe laboratory environment.

Facilities Management at the University of Colorado Boulder (http://www.colorado.edu/facilitiesmanagement/) further ensures a safe working environment. The Mission of Facilities Management is "To plan for and provide a physical and operational environment that supports the University of Colorado Boulder's mission of education, research and outreach." One of the core values of Facilities Management is "A safe environment" and Facilities Management supports this value by providing waste removal, custodial services, pest management, recycling, the fire alarm and fire sprinkler systems, landscaping, snow removal, and safe steam and electricity generation. All of these support services contribute to the overall safety of students in the program.

The Engineering Center is generally open Monday-Thursday from 7 a.m. to 1 a.m., Friday from 7 a.m. to 10 p.m. and Saturday and Sunday 8 a.m. to 10 p.m. The Discovery Learning Center (DLC) is open Monday-Friday from 7 a.m. to 7 p.m.; and the Integrated Teaching and Learning Lab (ITLL) is open Monday-Thursday 8 a.m. to 11 p.m., Friday 8 a.m. to 5 p.m., and Sunday 1 p.m. to 11 p.m.

CRITERION 8. INSTITUTIONAL SUPPORT

A. Leadership

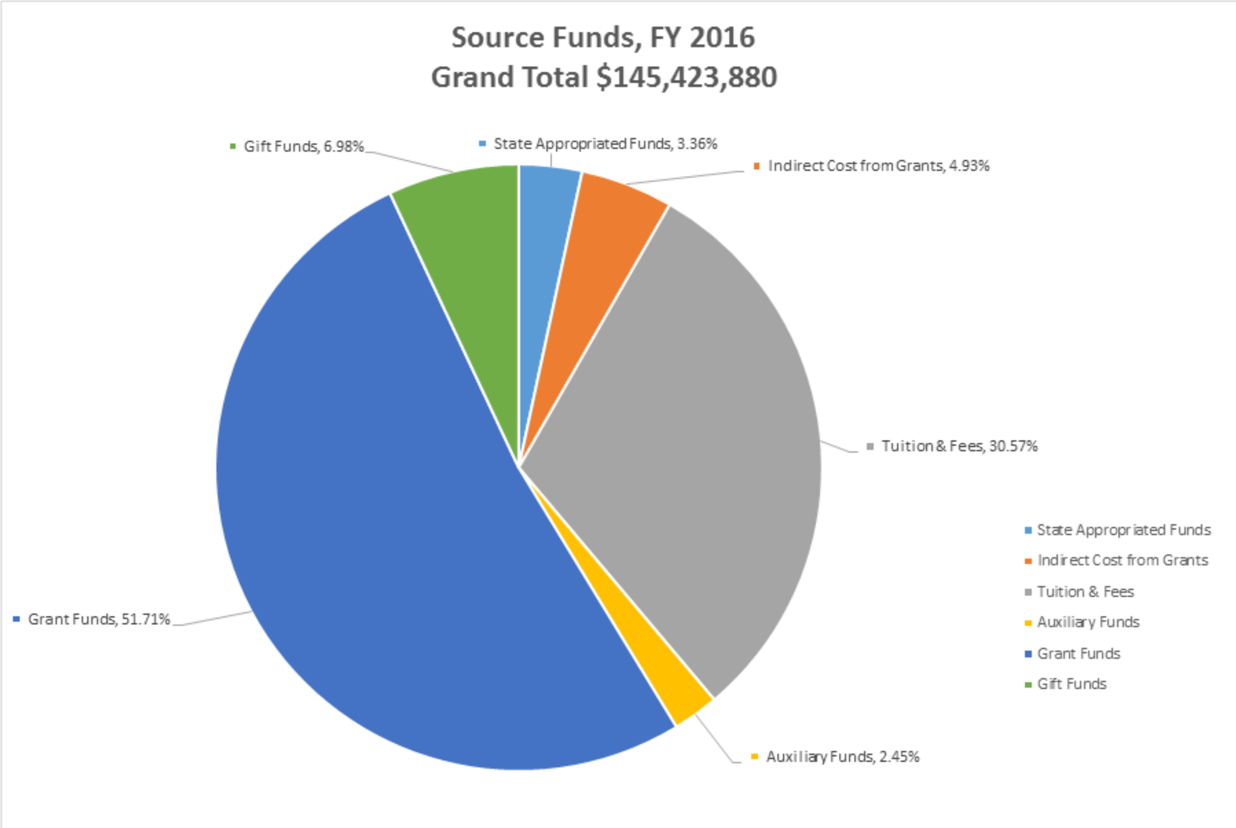
The CEAE department is the sole home for the civil engineering Bachelor's degree; it also is the sole home of the architectural engineering Bachelor's degree and supports the environmental engineering degree (which is a college-wide program with various affiliated faculty that is administratively supported by CEAE). Faculty members in the CEAE department are represented in six traditional civil/architectural engineering groups for administrative purposes:

- construction engineering & management (with equal commitment to civil and architectural engineering),
- environmental (with commitment to civil and environmental engineering),
- geotechnical (fully devoted to civil engineering),
- structural engineering & mechanics (with equal commitment to civil and architectural engineering),
- water resources (committed to civil engineering, and some support environmental engineering)
- building systems (devoted to architectural engineering)

The CEAE department has a democratic governance structure with collaborative planning and decision making. The Department chair is elected by the faculty (inclusive of those from civil and architectural engineering), with final appointment by the Dean; until now the Dean has not gone against the wishes of the faculty. The department chair is the chief administrative officer. The CEAE Department is led by the Chair and the Executive Committee. Professor Keith Molenaar was elected in 2010 and served one 4-year term until 2014. Professor Balaji Rajagopalan was elected in 2014 and is still serving. Each of the six departmental sub-groups nominates a member for the executive committee, who is then approved (or not) by a vote of the entire CEAE faculty for a three-year term. CEAE faculty are also assigned to standing committees which are considered sub-committees of the Executive Committee: Curriculum (chaired by the Associate Chair for Undergraduate Education), Graduate (chaired by the Associate Chair for Graduate Education), Facilities, Personnel (Promotion) and Operations. Ad hoc committees can be formed by the faculty to serve special purposes. Current ad hoc committees include Awards, Mentoring, Research, and Computing. Rostered instructors and research professors are voting members of the faculty and serve on the standing committees of the department, including the Executive Committee. The faculty governance structure is one of the strengths of the department. The representative structure of each sub-discipline area on the executive committee ensures that all faculty have a voice in the direction of the program. The leadership structure is adequate to ensure the direction, continuity, and quality of the program.

B. Program Budget and Financial Support

The expenditures by the College of Engineering and Applied Science for FY16 were $145.4 M from the following sources:

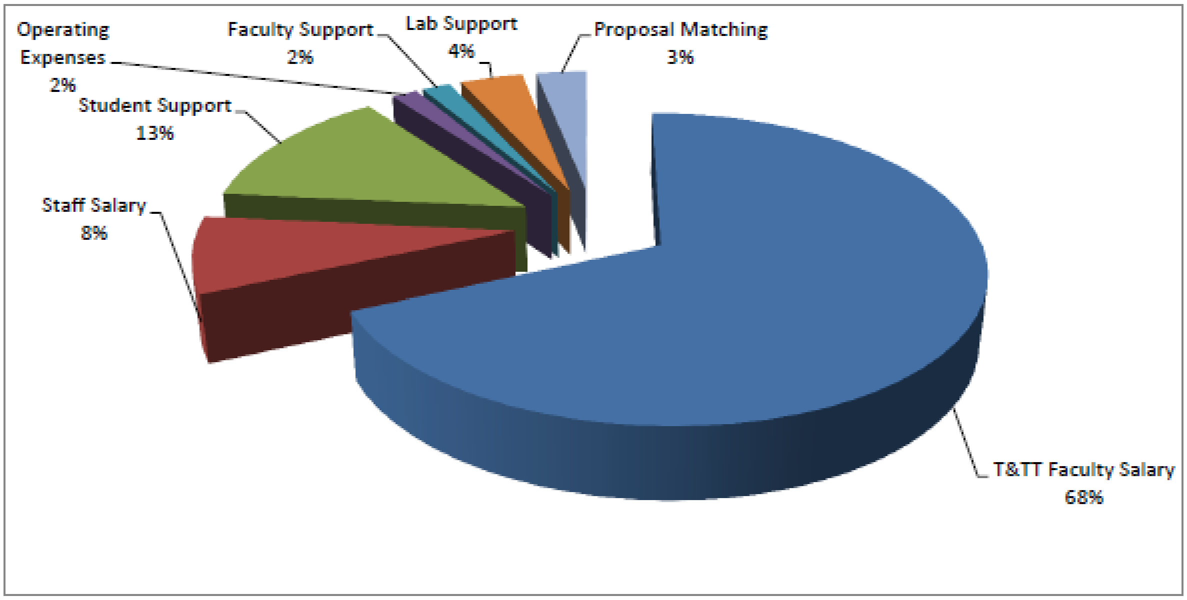


The College distributes the general fund budget (monies from tuition and fees, state funds, and indirect costs from grants) to the departments and programs in specific categories (ex., faculty salaries, staff salaries, TA stipends, operating funds) using well-defined formulas, established by the dean with advice from and discussion with the department chairs. These formulas are based on input data such as enrollments, student credit hours, and research expenditures.

The Department receives its budget from the College of Engineering and Applied Science through (1) allocation of faculty positions, (2) funds to cover staff and teaching assistant salaries and operating expenses, and (3) recovery of indirect costs from grants and contracts. In addition, the Department has several gift endowments totaling approximately $2.5 million, which generate about $100,000 per year in income for support of educational equipment and student activities. The staff, teaching assistant, and operating budgets are determined based primarily on student credit hour (SCH) generation, the number of undergraduate and graduate students in the Department's programs, and the number of faculty in the Department. Funds for additional teaching support are added when the SCH generation per faculty member exceeds the College average. The CEAE department chair and staff, with inputs from the Executive Committee, creates budget based upon teaching, research, and administrative needs. The budget is presented to the Executive Committee for approval each fall with updates throughout the year as necessary.

A portion (approximately 15%, plus 8% embedded in staff salaries) of the indirect costs recovery (ICR) from faculty's sponsored research activities is returned to the Department to augment its operating budget. In addition, the endowments to the Department also produce an income stream that is used for purposes specified in the original donations, such as acquisition of instructional equipment, funding of student scholarships, and funding of named lecture series.

Breakdown of the Department expenditures for FY2016 were $6.9 M from the sources shown below.



Funding of senior instructors and lecturers has increased 68% from $313,142 in 2010 to $524,434 in 2016. Although resources have been strained largely due to increasing student enrollment in our courses, they continue to be sufficient to enable us to meet our student outcome goals.

C. Staffing

The CEAE Department has an excellent staff to support the civil engineering program, consisting of an administrative assistant/office manager (Araceli Warren), an undergraduate advisor/program coordinator for Civil Engineering (Christina Vallejos), a graduate program coordinator (Ken LaFon), an office receptionist (Trinh Hansen), a financial services manager (Krista Bradley), an accounting technician (Lynn Shirk), and a web design specialist (Laurence Lambert); a part-time communications specialist (Emily Adams) also serves the program. As well, the undergraduate advisor/program coordinator for Architectural Engineering (Erin Jerick) can fill-in when the Civil Engineering advisor is absent. Part-time student assistants are hired on an as-needed basis to assist with special activities demanding more staff time.

The Department supports its teaching labs through two staff members. One Professional Research Assistant/Lab Manager (Simon Petit) supports the Centrifuge Laboratory, and Geotechnical Engineering lab courses, another Professional Research Assistant/Lab Manager supports research and teaching activities in the Structures, Materials and Teaching Laboratory. In addition, the department provides partial support for a lab manager (Dorothy Noble) to support the Environmental Engineering Laboratory that is shared by several faculty and students. The Department has a contract with the University's Office of Information Technology (OIT) to provide desktop support to faculty and staff, and to its Bechtel Lab Computer Lab. This OIT contract is equivalent to approximately a half-time position. The Department supports the Laboratory positions through its operating budget. The OIT contract is supported through program fees.

The Department participates in the College's Staff Excellence Program. The program funds (i) opportunities for staff training and professional development, (ii) performance-recognition awards, (iii) a peer-mentoring program, and (iv) engagement in social events and college activities. The Department financially supplements the College's program to assist in professional development for the staff. Professional development and training strengthen staff members' capabilities to take on additional responsibilities, (e.g. the latest upgrade of the Human Resource and Financial Systems, CU Marketplace, Concur Expense system, CU-SIS student information system, and the new graduate application system). Staff are also given the opportunity to enroll in job-related or career enhancing classes on campus, taking advantage of the tuition benefit of 9 credit hours per academic year. Staff arrange work time, if necessary, with their supervisor, to take these classes.

The staff budget allocation from the College has increased by 94% ($268,872 in 2010 to $ 522,329 in 2017), as a reflection of the overall growth in research expenditures and student enrollment. The Department hopes to add staff in the coming years to accommodate the continued growth of student enrollment.

D. Faculty Hiring and Retention

The Dean, with advice from and discussion with the department chairs, assigns new and replacement (losses due to retirements, resignations, etc.) faculty lines to departments. Each department is required to produce a recruiting plan for each faculty line for which the department will be searching. The department is responsible for advertising for the position, forming the search committee, selecting candidates for interviews, etc. In some cases, the search will be for an interdisciplinary faculty member. In those cases, the search committee will have members from several departments. Detailed information about the procedures for faculty hiring are found at http://www.colorado.edu/engineering-facultystaff/hiring. When the department has selected its preferred faculty hire, the Dean must then approve the individual. Note that if a faculty is being hired with tenure, the individual must be reviewed through the entire standard tenure process (review by primary unit, first level review, Dean, VCAC, and eventually approved by the Regents).

To retain current qualified faculty, the University benchmarks its salary and benefits against peer institutions. Per the availability of the raise pool determined for the campus each year, raises are awarded based on merit, as established by annual ratings in research, service, and teaching. The CEAE Department, in coordination with the College and University, can also offer a retention package if a faculty member has a competing offer from another university. Retention packages vary, but typically include salary increases, student support, lab space or other items to entice the faculty to stay. Raises can also be awarded if a faculty member demonstrates that their salary lags behind peers in CEAE with similar merit ratings.

E. Support of Faculty Professional Development

The University offers excellent opportunities to grow one's teaching abilities through the Faculty Teaching Excellence Program (FTEP; http://www.colorado.edu/ftep/). FTEP has two programs targeted specifically at helping new tenure-track faculty: the New Assistant Professor Program and the Early Career Faculty Program: Faculty Learning Communities. FTEP offers a variety of workshops and seminar events open to any faculty member each semester. They also offer one-on-one consultations such as classroom learning interviews, videotape consultation, and teaching portfolio consultations. FTEP coordinates the President's Teaching Scholars Program to promote the scholarship of teaching and learning; CEAE participants have included Matt Hallowell (2013) and Lupita Montoya (2011). FTEP coordinates the President's Teaching Scholars Program (PTSP), of which two CEAE faculty are members (Roseanna Neupauer and Hari Rajaram).

The College supports the professional development of faculty through the Faculty Excellence Program, which was described previously in Section 6D.

The Department encourages professional development through the attendance of conference and workshops. Data are collected on faculty attendance of these events through the annual reporting and evaluation process. If faculty members are not participating in these events, it is noted by the chair. New faculty members have significant start-up packages with moneys designated for travel and professional development. Senior faculty members typically raise their own funds for travel to these events, but they can also make request of the Department or College on a case-by-case basis. For example, the department paid for the ABET assessment coordinator to attend the Spring ABET symposium. All faculty members are encouraged to use the significant on-campus resources for professional development as well.

PROGRAM CRITERIA

The program criteria for civil engineering programs include requirements for both curriculum and faculty. Each of these requirements and how the CU Civil Engineering program fulfills the requirement are explained below.

1.1 The curriculum must prepare graduates to: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science;

All Civil Engineering students in the BS program take 33 credits of math and basic sciences, including three semesters (12 credits) of calculus, one semester of differential equations and linear algebra (4 credits), two semesters of calculus-based physics with a laboratory (9 credits), one semester of basic chemistry with a laboratory (5 credits), and engineering geology or another basic science (3 credits). [These courses are shown on the block diagram in section 5.A and associated Table 5-1.]

For the basic science course, students can select from among:

ATOC 1050 (3) Weather and the Atmosphere
Introduces principles of modern meteorology for nonscience majors, with emphasis on scientific and human issues associated with severe weather events. Includes description, methods of prediction, and impacts of blizzards, hurricanes, thunderstorms, tornadoes, lightning, floods, and firestorms.

ATOC 1060 (3) Our Changing Environment: El Nino, Ozone, and Climate
Discusses the Earth's climate for nonscience majors, focusing on the role of the atmosphere, oceans, and land surface. Describes the water cycle, atmospheric circulations, and ocean currents, and how they influence global climate, El Nino, and the ozone hole. Discusses human impacts from climate change. Prereq., ATOC 1050.

CVEN 3698 (3) Engineering Geology
Highlights the role of geology in engineering minerals; rocks; surficial deposits; rocks and soils as engineering materials; distribution of rocks at and below the surface; hydrologic influences; geologic exploration of engineering sites; mapping; and geology of underground excavations, slopes, reservoirs, and dam sites. Includes field trips. Requisites: Requires a prerequisite or corequisite course of CVEN 2121 or GEEN 2851 or ASEN 2001 or MCEN 2023 and APPM 2350 or MATH 2400 (all minimum grade C-). *Many CVEN students take this course; as such, the syllabus is included in Appendix A and a course dossier has been prepared as part of the display materials.*

GEOL 1010 (3) Introduction to Geology
Introductory geology for majors and non-majors. Studies Earth, its materials, its characteristics, its dynamic processes, and how it relates to people.

EBIO 1030 (3) Biology: A human Approach 1
Studies the principles of biology and their implications. Central theme is humans and the environment, emphasizing ecology, natural resource conservation, and the interrelatedness of a growing human population.

EBIO 1210 (3) General Biology 1
Provides a concentrated introduction to molecular, cellular, genetic, and evolutionary biology. Emphasizes fundamental principles, concepts, facts, and questions.

Performance in subsequent engineering courses both depends on and reinforces students' basic knowledge in mathematics, physics, and chemistry. Calculus and differential equations (APPM 1350, 1360, 2350, 2360) and Physics 1 (PHYS 1110) are prerequisites for all fundamental engineering courses in Civil Engineering. Basic chemistry (CHEM 1221 and CHEN 1211) is prerequisite for the required course Fundamentals of Environmental Engineering (CVEN 3414). These courses are in turn pre-requisites for the various proficiency and CEAE elective courses.

Measures of students' attainment of proficiency in math and basic science depends on internal measures such as student work in civil engineering courses requiring application of these fundamentals, and on external measures such as the Fundamentals of Engineering (FE) Examination. As described above in section 4B for student outcome 1, our direct and indirect evidence indicates adequate student fulfillment of this outcome.

1.2 The curriculum must prepare graduates to: apply probability and statistics to address uncertainty

All Civil Engineering students are required to take a three-credit course in probability, statistics, and decisions (CVEN 3227, junior year). The course description is: "Introduces uncertainty based analysis concepts and applications in the planning and design of civil engineering systems emphasizing probabilistic, statistics, and design concepts and methods." A syllabus for the course is included in Appendix A.

1.3 analyze and solve problems in at least four technical areas appropriate to civil engineering

The current curriculum requires all civil engineering students to take a fundamental level course in five technical areas of civil engineering (construction, environmental, geotechnical, structures, and water resources). These courses are recommended to be taken in fall of the junior year. Each course includes analyzing and solving problems. The FE exam results seem to indicate sufficient levels of knowledge across these five topic areas. As well, students routinely rate problem solving high in these five fundamental courses, as shown below.

Technical Area	Required Fundamental Course	Student FCQ rating for problem solving (0-6)
Construction	CVEN 3246 Introduction to Construction	4.3 – 5.1
Environmental	CVEN 3414 Fundamentals of Environm Eng	4.1 – 5.2
Geotechnical	CVEN 3708 Geotechnical Engineering 1	3.7 – 5.2
Structures	CVEN 3525 Structural Analysis	3.5 – 5.6
Water resources	CVEN3323 Hydraulics	5.3 – 5.5

1.4 conduct experiments in at least two technical areas of civil engineering and analyze and interpret the resulting data;

There are three courses that all civil engineering students are required to take that include embedded laboratories:
CVEN 3161 Mechanics of Materials (related to the structural area of civil engineering)
CVEN 3323 Hydraulic Engineering (related to the water resources area of civil engineering)
CVEN 3708 Geotechnical Engineering 1 (related to the geotechnical area of civil engineering)

Course	Role	Hours of Lab / semester	# of laboratory projects	Student FCQ rating	
				Design and conduct experiments	Analyze and interpret data
CVEN 3161 Mechanics of Materials 1	Required	30	3 or 4	3.7 - 4.4	4.2 – 5.1
CVEN 3323 Hydraulics	Required	18	4	4.5 – 4.9	5.0
CVEN 3708 Geotechnical Engineering 1	Required	12	6	4.2 – 5.0	4.7 – 5.2

1.5 design a system, component, or process in at least two civil engineering contexts;

The proficiency courses in civil engineering include design, with the exception of the water resources course Hydrology - because the fundamental Hydraulics course required for all students is design-intensive. Student select three proficiency courses in three different proficiency areas; fundamental courses are required in all five areas. This ensures that all students experience design in a minimum of three civil engineering contexts. Faculty and student ratings of the extent of design in these courses is shown below.

Context	Courses (R = required, P = proficiency)	Student FCQ design	Faculty Rating of Design		
			Large	Medium	Small
Construction	CVEN3256 Construction Equip & Methods (P)	*4.6-5.5*	*1*		
	CVEN 3246 Introduction to Construction (R)			***1***	
Environmental	CVEN 3424 Water & WW Treatment (P)	*5.5-5.6*	*1*		
	CVEN 3414 Fundamentals of Environml Eng (R)				*1*
Geotechnical	CVEN 3718 Geotechnical Engineering 2 (P)	*4.0-4.6*			*1*
	CVEN 3708 Geotechnical Engineering 1 (R)				*1*
Structures	CVEN 4545 Steel Design (P)	*5.4*	*1*		
	Or 4555 Reinforced Concrete Design (P)	*4.5-5.0*			
Water Resources	CVEN 4333 Hydrology (P)	*3.2-3.7*			*1*
	CVEN 3323 Hydraulics (R)	*5.0-5.6*	*1*		

1.6 include principles of sustainability in design

The first time that civil engineering students include the principles of sustainability in design is in the CVEN 1317 Introduction to Civil Engineering course in their first semester. The students are grouped into teams and must design a truss bridge using the Bridge Designer online program. For the class the bridges are judged on factors that map to the three pillars of sustainability: cost (economic), environmental impacts, social factors (aesthetics, etc.), and deflection (relates to safety). This follows a homework assignment on sustainability where they have been introduced to the ENVISION sustainable infrastructure rating system.

Later in their senior capstone design course, students are encouraged to apply the ENVISION rating system in their design; ENVISION is reintroduced in the Professional Issues course the preceding semester. In the senior capstone course, CVEN 4899, students evaluate and design sustainability features in their projects. Students provide design solutions for their client after considering life-cycle costs, material availability, renewable sources, energy consumption and the long and short-term impact on the environment and public health. These solutions are conveyed to their client in their base design and through value alternatives.

1.7 explain basic concepts in project management, business, public policy, and leadership

These elements are all included within the Professional Issues course. There are lectures and three homework assignments that relate to these topics: Business and Public Administration; Public Policy; and Leadership vs. Management. Project management is covered in the CVEN 3246 introduction to Construction course that is required for all students (fall junior year).

1.8 analyze issues in professional ethics

The required Introduction to Civil Engineering course in the first year introduces students to the ASCE Code of Ethics and presents case studies for examination. However, these cases are reasonably straight-forward. The required fundamental course in construction, CVEN 3246 Introduction to Construction, is typically taken in the fall of the junior year and includes ethics. The required Professional Issues course in the senior year takes a more sophisticated approach to ethics, including macroethical issues. Students analyze ethical issues related to New Orleans levees/Hurricane Katrina (pre/during/post event). The ethics-related assignment in the Professional Issues course is worth 17% of the students' overall grade in the 2-credit course.

1.9 explain the importance of professional licensure

The 2016 Structures JEC noted a concern that students do not exhibit a good understanding of requirements to become a licensed PE. However, there are two points in the curriculum where this information is presented and students must demonstrate their knowledge on graded assignments.

In the Introduction to Civil Engineering course, students are introduced to the process to became a licensed PE and why it is important; the ethics homework assignment asks students to share their ideas on this issue.

> **Homework 4. Part 5. Professionalism** [16 pts of 500 for whole 2-credit course]
> a) **List**, in chronological order, the typical steps required to become a licensed Professional Engineer (PE). {4 pts}
> (included in the ASCE BOK2 http://www.asce.org/CE-Body-of-Knowledge/ and general overview at http://www.nspe.org/resources/licensure/how-get-licensed)
>
> b.) **Discuss** why licensure is so important for Civil and/or Architectural Engineers {5 pts} (in BOK2 see pg. 9 Figure 1; also read BOK2 pgs. 6-9 and pgs. 21-22 and information from ASCE Raise the Bar http://www.asce.org/raise_the_bar/)
>
> c) Select five of the "attitudes" listed in the ASCE BOK2 Outcome 22 that you believe are most important for professional engineers and for each describe why it is important. {4 pts}
>
> d) Do you think a Master's degree or 30 additional credits of coursework should be required for professional licensure? Why or why not. {3 pts} [http://www.raisethebarforengineering.org/voices-support]

In the Professional Issues course that is required in the senior year, the importance and process for professional licensure is reinforced. The definition of a profession is explored. The ASCE BOK2 is explored, and students also discuss and reflect on the Raise the Bar requirements for PE licensure. Within assignment 3 in the course the most relevant question is:

> 5. [6 pts] Explain the typical process of becoming a professionally licensed engineer and maintaining a professional engineering license. Discuss how this might change in the future and why. Discuss how this process helps to ensure that engineers can uphold their ethical responsibilities to protect human and environmental health and welfare. {your answer should be about 300-500 words long; Figure 1 in the BOK summarizes this process, but your answer should provide more detail on these basic steps}

All students are required to take the NCEES Fundamentals of Engineering (FE) exam prior to graduation. This sets them on the path to becoming a licensed Professional Engineer (PE).

2.1 Faculty Qualifications to Teach Design

"The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience." (ABET, EAC, 2017-2018, p. 12)

For the capstone design course in civil engineering, a team of four faculty routinely teach the course. In recent years, the course is coordinated and led by senior instructor Matt Morris, who is a licensed Professional Engineer in the State of Colorado and a LEED Accredited Professional. Other instructors vary somewhat each term. Each term the course includes a minimum of one instructor who is a licensed PE. Instructors are summarized below:

CVEN 4899 Instructors

Term	Instructor Team
Fall 2012	Balaji (water), McCartney (geotech), Morris (construction, PE), Saouma (structures)
Fall 2013	Morris (construction, PE), Balaji (water), Corotis (structures, PE), Znidarcic (geotech)
Fall 2014	Morris (construction, PE), Balaji (water), Corotis (structures, PE), Znidarcic (geotech)
Fall 2015	Morris (construction, PE), Balaji (water), Corotis (structures, PE), Dashti (geotech)
Spring 2016	Morris (construction, PE), Balaji (water), Hubler (structures), Sture (geotech, PE Norway)
Spring 2017	Morris (construction, PE), Balaji (water), Sideris (structures; PE-equivalent Greece), Dashti (geotech)

For the instructors who are not PEs (as noted in the table above), design experience is summarized below with more detail provided in the individual resumes in Appendix B.

Name	**Summary of Design Experience for Design Course Instructors Not PEs**
Balaji	Associate Research Scientist LDEO, Columbia University; interned with Alembic Chemicals, Hindustan Cables Ltd and Engineers India Ltd.
Dashti	2004-2006 worked with ARUP (New York City) and Bechtel (San Francisco) Geotechnical groups, where worked on several engineering projects in the US and around the world involving the design of foundation systems, slopes, and underground structures and tunnels.
Hubler	Prof. Hubler's research addresses structural evaluation and redesign, including development's in the design code. This expertise is enacted through professional service including: Voting Member for ACI 209 Creep and Shrinkage of Concrete, 2012 – 2013, secretary for subcommittee on rate type modeling; RILEM Technical Committee MDC – Multi-decade creep and shrinkage of concrete: material model and structural analysis, 2012-2013.
McCartney	TRI/Environmental, Austin, TX, Laboratory Consultant, 2006-2013;

Name	Summary of Design Experience for Design Course Instructors Not PEs
(no longer at CU)	Colorado Department of Public Health and Environment, Research Intern, 2000-2001
Saouma	Served as a consultant for 22 companies and agencies (including the U.S. Army Corps of Engineers, US Bureau of Reclamation, Weidlinger & Assoc.); developed 7 major software packages that are still active; over 100 technical reports written to sponsors; expertise in dams, fracture mechanics, and modeling concrete deterioration
Sideris	Licensed Engineer, Technical Chamber of Greece, Athens; 2009-present (http://www.teepatra-old.tee.gr/tcg.htm)
Znidarcic	Numerous consulting assignments with industry on sanitary landfills, dredging, power plants and site remediation

The instructors for other required or proficiency courses in the curriculum with large design elements are shown below.

	Required CVEN 3323 Hydraulics	Proficiency CVEN 3256 Constr Equip & Methods	Proficiency: CVEN 3424 Water & Wastewater Treatment	Proficiency: Geotech I	Proficiency: CVEN 4545 Steel Design	Proficiency: CVEN 4555 Reinforced Concrete Design
Instructor	Neupauer (PE)	Goodrum (PE) Hallowell (5 yr exp) Novak	Corwin (PE) Summers	Pak Regueiro Znidarcic Dashti McCartney	Hearn (PE)	Hearn (PE) Nguyen

A brief summary of the design experience for each of these individuals without a PE license and not previously described for senior design above is provided below.

Matthew Hallowell, Ph.D., design experience as:
president and lead engineer at Modular Design solutions in Corvalis, OR
structural engineer at Penn Lyon Homes in Selinsgrove, PA
project engineer at Pine Tree Engineering in Bath, ME (highway design)

Lan Nguyen, Ph.D.
Earned her PhD in structural engineering from CU in 2014. She worked as a structural engineer at Aero Solutions LLC from 2011-2013, including designing tower structural elements such as foundations and upgrades for stability. As a graduate research assistant she design reinforced concrete frames and masonry shear wall panels. She served as an Adjunct Instructor for the Reinforced Concrete Design class in fall 2014. She has since earned her P.E. license.

Ryan Novak, M.S., 3 years as project manager for Erdman; 4 years as project industrial manager for UOP within a design-build delivery system (oversaw the design, fabrication, and installation of variety of mechanical product lines)

Ron Pak, Ph.D., Assoc. Engineer CF Braun & Co. 1981-1982; Assistant Structural Designer in 1979 for Chau, Lee, & She Architects & Engineers; consulting

Richard A. Regueiro, Ph.D. Prior to joining the faculty at CU, Prof. Regueiro served as a lecturer at Stanford University and a member of the technical staff of the science-based materials modeling department at Sandia National Laboratories for 7 years. He develops models for simulating ineslastic deformation and failure in saturated and partially saturated soils and rock and bound particulate materials (e.g. sandstone, asphalt, concrete).

R. Scott Summers, Ph.D., was a research engineer at the U.S. EPA ORD for 2 years; has served as a consultant on more than 40 treatment studies for drinking water utilities; was a consultant to the USEPA's Regulatory-Negotiations Committee (1992-94) and the Federal Advisory Committee Act process (1996-2001) for USEPA's Microbial/Disinfection Byproduct Rule cluster; chaired the USEPA/ AWWA Research Foundation Microbial/ Disinfection Byproduct Research Council, Research Advisory Committee (1997 – 2000); was a consultant to the USEPA's National Drinking Water Advisory Council Arsenic Cost Working Group (2001) and on several CALFED related projects (1995-2004); and was a meeting facilitator and technical consultant on five USEPA and AWWA workshops (2004-05) on the implications of the Lead and Cooper Rule, including simultaneous compliance issues with other rules.

2.2 The program must demonstrate that it is not critically dependent on one individual.

There are multiple individuals among the CEAE faculty who are able to teach all of the courses in the curriculum. Many of the courses rotate among faculty on a routine basis, while other courses have typical instructors and others fill in during sabbatical and other leaves. The table below summarizes the various instructors for the required courses for the B.S. degree in CVEN over the past seven years. With our large faculty size, our program is not critically dependent on any individual.

Course (Department, Number, Title)	**Instructors 2010-present**
CVEN 1317 Introduction to Civil and Environmental Engineering	Bielefeldt, Brandemeuhl (ret.)
CVEN 2012 Introduction to Geomatics	Halek, Pfeffer
AREN 1027 Engineering Drawing	Atkins, Wirth, Cayko, Core, Al-Rubaiy
CVEN 2121 Analytical Mechanics 1	Sideris, Keely, Song, Cho, Znidarcic, Ghayoomi, Soudkhah, Mitchell, Sivaselvan
AREN 2110 Thermodynamics	Silverstein, Hernandez, Handorean, Montoya
CVEN 3313 Theoretical Fluid Mechanics	Rajaram, Crimaldi, Arshadi
CVEN 3161 Mechanics of Materials 1	Vernerey, Xi, Cho, Srubar, Hubler
CVEN 3698 Engineering Geology	Amadei, Pfeffer
CVEN 3246 Introduction to Construction	Hallowell, Harper, Morris, Novak
CVEN 3323 Hydraulic Engineering	Neupauer, Soltys
CVEN 3525 Structural Analysis	Corotis, Saouma, Cho

Course (Department, Number, Title)	Instructors 2010-present
CVEN 3414 Fundamentals of Environmental Engineering	Ryan, Linden, Dotson, Rosario-Ortiz, Writer, Ling, Parker, Corwin
CVEN 3708 Geotechnical Engineering 1	McCartney, Regueiro, Znidarcic, Pak, Dashti
CVEN 3227 Probability and Statistics	Liel, Corotis
CVEN 3111 Analytical Mechanics 2	Dow, Amadei, Keely, Vernerey, Song
CVEN 4899 Senior Design Project	See previous
Proficiency: CVEN 3424 Water and Waste Water Treatment	Summers, Corwin
Proficiency: CVEN 3256 Construction Equipment & Methods	Forcael, Hallowell, Goodrum, Novak
Proficiency: CVEN 3718 Geotechnical Engineering 2	Znidarcic, Pak, Regueiro, Dashti
Proficiency: CVEN 4333 Hydrology	Chase, Gill, Kasprzyk, Livneh
Proficiency: CVEN 4545 Steel Design or CVEN 4555 Reinforced Concrete Design	Hearn, Cook, Nguyen

APPENDICES

Appendix A – Course Syllabi

A 2-pg summary of each of the required and proficiency courses for CVEN students is included in this section. These are presented in alpha-numeric order.

Course number, name	**APPM 1350 Calculus 1 for Engineers**	
Credits and contact hours	4-credits, three 50-min lectures per week and one 50-min recitation per week	
Instructor(s)	Prof. Anne Dougherty, course coordinator (numerous different instructors)	
Textbook, Other materials	Essential Calculus 2nd edition. James Stewart, 2013. WebAssign online homework system (requires subscription)	
Course description	Topics in analytical geometry and calculus including limits, rates of change of functions, derivatives and integrals of algebraic and transcendental functions, and applications of differentiation and integration. Students with credit in APPM 1350 may not receive credit for MATH 1080, 1081, 1090, 1100, 1300, 1310, or ECON 1088	
Prerequisite(s)	Requires prerequisite course of APPM 1235 or MATH 1021 or MATH 1150 or an ALEKS math score or 76% or greater.	
Required or elective	Required for all students in degree program	
Course learning objectives	(1) Understand the concepts, techniques and applications of differential and integral calculus, and (2) improve problem solving and critical thinking.	
Relationship of course to program outcomes	<u>Program Outcome</u>	<u>Emphasis</u>
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	6. an ability to identify, formulate, and solve engineering problems	Small
List of topics covered	Limit of a Function; Continuity; Derivatives and Rates of Change; Basic Differentiation Formulas; Chain Rule; Implicit Differentiation; Related Rates; Linear Approximations and Differentials; Maximum and Minimum Values; Mean Value Theorem; Curve Sketching; Optimization Problems; Newton’s Method; Antiderivatives; Areas and Distances; Definite Integral; Fundamental Theorem of Calculus; Substitution Rule; Inverse Functions; Natural Logarithmic Function; Exponential Functions; Exponential Growth and Decay; Inverse Trigonometric Functions; Hyperbolic Functions; Indeterminate Forms and l’Hospital’s Rule	
Contribution to the professional component	100% Math and Basic Science	

Course number, name	**APPM 1360 Calculus II for Engineers**	
Credits and contact hours	4-credits, three 50-min lectures per week and one 50-min recitation per week	
Instructor(s)	Brian Zaharatos, course coordinator (numerous different instructors)	
Textbook, Other materials	Essential Calculus 2nd edition. James Stewart, 2013. WebAssign online homework system (requires subscription)	
Course description	Continuation of APPM 1350. Focuses on applications of the definite integral, methods of integration, improper integrals, Taylor's theorem, and infinite series. Credit not granted for this course and MATH 2300.	
Prerequisite(s)	Requires prerequisite course of APPM 1345 or APPM 1350 or MATH 1300 (minimum grade C-).	
Required or elective	Required for all students in degree program	
Course learning objectives	(1) Understand the concepts, techniques and applications of differential and integral calculus, (2) to understand sequences and series, and (3) to improve problem solving and critical thinking.	
Relationship of course to program outcomes	<u>Program Outcome</u>	<u>Emphasis</u>
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	6. an ability to identify, formulate, and solve engineering problems	Small
List of topics covered	Integration by Parts; Trigonometric Integrals and Substitutions; Partial Fractions; Improper Integrals; Areas between Curves; Volumes; Volumes by Cylindrical Shells; Arc Length; Applications of Integration to Physics and Engineering; Differential Equations; Sequences; Series; The Integral and Comparison Tests; Other Convergence Tests; Power Series; Representing Functions as Power Series; Taylor and Maclaurin Series; Parametric Curves; Calculus with Parametric Curves; Polar Coordinates; Areas and Lengths in Polar Coordinates.	
Contribution to the professional component	100% Math and Basic Science	

Course number, name	**APPM 2350 Calculus III for Engineers**
Credits and contact hours	4-credits, three 50-min lectures per week and one 50-min recitation per week
Instructor(s)	Prof. Adam Norris, course coordinator (numerous different instructors)
Textbook, Other materials	Essential Calculus 2nd edition. James Stewart, 2013. WebAssign online homework system (requires subscription) Additional materials to students via Desire2Learn (D2L)
Course description	Covers multivariable calculus, vector analysis, and theorems of Gauss, Green, and Stokes. Credit not granted for this course and MATH 2400.
Prerequisite(s)	Requires prerequisite course of APPM 1360 or MATH 2300 (minimum grade C-).
Required or elective	Required for all students in degree program
Course learning objectives	This course extends the ideas of single-variable calculus (e.g. differentiation, integration, optimization) to functions of several variables.
Relationship of course to program outcomes	<u>Program Outcome</u> — <u>Emphasis</u> 1. an ability to apply knowledge of mathematics, science, and engineering — Large 6. an ability to identify, formulate, and solve engineering problems — Small
List of topics covered	Vectors in the Plane; Cartesian (Rectangular) Coordinates and Vectors in Space; Dot Products; Cross Products; Lines and Planes in Space; Cylinders and Quadric Surfaces; Vector-Valued Functions and Space Curves; Arc Length and the Unit Tangent Vector T; Curvature, Torsion, and the TNB Frame; Functions of Several Variables; Limits and Continuity; Partial Derivatives; Differentiability, Linearization, and Differentials; The Chain Rule; Directional Derivatives, Gradient Vectors, and Tangent Planes; Extreme Values and Saddle Points; Lagrange Multipliers; Taylor's Formula; Double Integrals; Areas, Moments, and Centers of Mass; Double Integrals in Polar Form; Triple Integrals in Rectangular Coordinates; Cylindrical and Spherical Coordinates; Triple Integrals in Cylindrical and Spherical Coordinates; Substitutions in Multiple Integrals; Line Integrals; Vector Fields, Work, Circulation, and Flux; Path Independence, Potential Functions, and Conservative Fields; Green's Theorem in the Plane; Surface Area and Surface Integrals; Stoke's Theorem; The Divergence Theorem and a Unified Theory.
Contribution to the professional component	100% Math and Basic Science

Course number, name	**APPM 2360 Differential Equations with Linear Algebra**
Credits and contact hours	4-credits, three 50-min lectures per week and one 50-min recitation per week
Instructor(s)	Nicholas Featherstone. James Meiss, Li Congming, Stephen Beckeer.
Textbook, Other materials	Differential Equations and Linear Algebra, by Farlow, Hall, McDill, & West, 2nd edition. https://www.colorado.edu/amath/course-pages/fall-2016/appm2360 for general info, homework assignments, past exams, tutoring options, pre-exam review sessions, exam rooms and times, and office hours. Desire2Learn (D2L) https://learn.colorado.edu for grades, homework solutions, and submitting projects
Course description	Introduces ordinary differential equations, systems of linear equations, matrices, determinants, vector spaces, linear transformations, and systems of linear differential equations. Credit not granted for this course and both MATH 3130 and 4430.
Prerequisite(s)	Requires prerequisite course of APPM 1360 or MATH 2300 (minimum grade C-).
Required or elective	Required for all students in degree program
Course learning objectives	Explain the importance of ordinary differential equations in science and engineering, identify appropriate analysis methods, and develop mathematical thinking with the exposure to abstract vector spaces. Categorize types of differential equations (ordinary/partial, linear/nonlinear, separable). Qualitative methods: construct and interpret direction fields and phase planes. Analytic methods: solve separable first-order equations, and inhomogeneous linear second-order equations. Laplace transform: know when to recommend the Laplace transform method, and to how to compute solutions to second-order. equations using the method. Linear algebra: explain the concept of a vector space, determine whether a given set of vectors are linearly independent, compute eigenvalues and eigenvectors, apply the methods of linear algebra to a system of linear differential equations.
Relationship of course to program outcomes	<u>Program Outcome</u> — <u>Emphasis</u> 1. an ability to apply knowledge of mathematics, science, and engineering — Large
List of topics covered	Solutions and Direction Fields; Separation of Variables; Approximation Methods' Picard's Theorem; Linear Equations; Solving First-Order Linear Equations; Growth and Decay; Mixing and Cooling; Nonlinear Logistic Equations; Systems of Equations; Matrices; Systems of Linear Equations; Matrix Inverse; Determinants; Vector Spaces; Basis and Dimension; Eigenvalues; Harmonic Oscillator; Real Characteristic Roots; Complex Characteristic Roots; Undetermined Coefficients; Variation of Parameters;

	Forced Oscillations; Conservation and Conversion' Laplace Transform; Solving Des with Laplace Transform; Step Function and Delta Function' Liner Systems with Real Eig.; Linear Systems w/Non-real Eig; Stability and Liner Classification.
Contribution to the professional component	100% Math and Basic Science

Course number, name	**AREN 1027 Engineering Drawing**
Credits and contact hours	Total Credits: 3 *Lecture 75-minutes 2x/week; Lab 110 min 1x/wk*
Instructors	Alex Gore and Lance Cayko
Textbook(s) and/or other required material	The LIFT student USB package. Included Templates, Revit Building Blocks, and Example files Optional: The Creativity Code: The Power of Visual Thinking ISBN-13: 978-0997927528
Course description	Students learn linetypes, symbols, drawing and dimensioning standards by generating drawings using drafting instruments and computer-aided-drafting. Drawings start with basic sketching, hand drafting and continue through 3-D solid modeling on Revit. Print reading includes interpretation of site, foundation, floor and roof plans as well as elevations and sections.
Required or elective	Required for all students in degree program
Prerequisite(s)	None
Course learning objectives	1. Draw and dimension working drawings using proper format 2. Draw a 3D solid model of a structure 3. Read and interpret working drawings

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Small
2. an ability to design and conduct experiments	Large
3. an ability to analyze and interpret data	Small
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Medium
5. an ability to function on multi-disciplinary teams	None
6. an ability to identify, formulate, and solve engineering problems	None
7. an understanding of professional and ethical responsibility	Small
8. an ability to communicate effectively through writing and drawings	Large
9. an ability to communicate effectively through oral presentations	Small

	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Large
	14. an ability to explain basic concepts in management, business, public policy, and leadership	Small
Topics covered	• Alphabet of lines. • Drawing symbols • Lettering and text • Drawing and dimensioning standards • Drawing notes and tables on working drawings • Sketches, geometric construction, working drawings, 3D models • Drawing problems on computer using both basic and advanced setup, drawing, editing, attributes and dimensioning commands • Working drawings including format and site, foundation, floor, roofing plans and section and detail drawings • Notes and tables on working drawings • Printing and plotting	
Contribution to the professional component	60% Engineering Science 40% Engineering Design	
Person(s) who prepared this description	Alex Gore	
Date of Preparation	2/07/2017	

Course number, name	**AREN 2110 Thermodynamics**
Credits and contact hours	3-credits, three 50-min lectures per week
Instructor(s)	Prof. Lupita D. Montoya, PhD
Textbook, Other materials	Cengel, Yunus A., John Cimbala, Robert H. Turner, Fundamentals of Thermal-Fluid Sciences, 4th Edition McGraw-Hill, 2012.
Course description	Explores fundamental principles of thermodynamics, including first and second law of thermodynamics, thermophysical properties, power and refrigeration cycles, gas mixtures and psychrometrics. Approved for arts and sciences core curriculum: natural science. Restricted to AREN, CVEN or EVEN, GEEN, AMEN or EVENCVEN Concurrent Degree majors only.
Prerequisite(s)	Requires a prereq course of PHYS 1110 (min grade C-) and a prereq or coreq course of APPM 1360 or MATH 2300 (min grade C-).
Required or elective	Required for all students in degree program

Course learning objectives

1. Analyze energy transfer and transformation in systems using fundamental concepts of properties of materials, work, heat, internal energy, entropy, equilibrium, and relations derived from the First and Second Laws of Thermodynamics.
2. Apply principles to simple compressible systems used in a variety of applications that sustain modern society – heating, cooling, electric and mechanical power generation.
3. Learn the methods to measure thermodynamic properties and estimate values for properties using property tables and relations.
4. Perform thermodynamic analysis of engineering devices and systems such as piston-cylinders, compressors, turbines, pumps, heat exchangers, heat engine cycles, and refrigeration cycles using energy, materials, and entropy relations.
5. Apply thermodynamic concepts in Civil, Environmental & Architectural Engineering such as sustainable energy technologies, energy conservation, and maintaining the global environment.

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Large
2. an ability to design and conduct experiments	None

	3. an ability to analyze and interpret data	Small
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	None
	5. an ability to function on multi-disciplinary teams	None
	6. an ability to identify, formulate, and solve engineering problems	**Large**
	7. an understanding of professional and ethical responsibility	None
	8. an ability to communicate effectively through writing and drawings	Small
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small
	11. a recognition of the need for, and an ability to engage in life-long learning	Small
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	**Large**
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Basic concepts in thermodynamics (e.g., system, state, equilibrium, cycle); Energy, energy transfer and general energy analysis; Properties of pure substances; Energy analysis of closed systems; Mass and energy analysis of control volumes; First and second law of thermodynamics; Entropy; Power and refrigeration cycles.	
Contribution to the professional component	100% Engineering Science	
Prepared by:	Lupita D. Montoya, 11/01/2016	

Course number, name	**CHEM 1221 Engineering General Chemistry Lab**
Credits and contact hours	Total Credits: 1 L*ab 2.5 hrs 1x/wk*

Instructor(s)	Various, including Tri Le, Jasper Cook
Textbook, Other materials	There is no textbook but there is a laboratory manual.
Course description	Meets general chemistry laboratory requirement for engineering students. Designed to illustrate chemical concepts and introduce basic techniques in chemical measurement and synthesis. Credit not granted for this course and CHEM 1113/1114 or CHEM 1251. Restricted to undergraduate engineering students only.
Prerequisite(s)	One year of high school chemistry or CHEM 1021 (min. grade C-) and high school algebra; B- in CHEM 1021 recommended. Requires prerequisite course of CHEN 1211 or CHEM 1133 (minimum grade C-), or corequisite course of CHEN 1211 or CHEM 1133.
Required or elective	Required for all students in degree program
Course learning objectives	• to learn how a chemist thinks and works • to discuss difficult points in small recitation classes • to develop experimental skills • to learn how to carefully observe and measure
Relationship of course to program outcomes	Program Outcome 1. an ability to apply knowledge of mathematics, science, and engineering — Large 2. an ability to design and conduct experiments — Large 3. an ability to analyze and interpret data — Large 4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability — None 5. an ability to function on multi-disciplinary teams — None 6. an ability to identify, formulate, and solve engineering problems — None 7. an understanding of professional and ethical responsibility — None 8. an ability to communicate effectively through writing and drawings — None 9. an ability to communicate effectively through oral presentations — None 10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context — None 11. a recognition of the need for, and an ability to engage in life-long learning — None

12. a knowledge of contemporary issues — None
13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice — None
14. an ability to explain basic concepts in management, business, public policy, and leadership — None

Topics covered

- Chemical reactions of copper
- How acidic is your vinegar?
- Atomic Spectroscopy
- Ionic and covalent compounds
- Enthalpy changes in chemical reactions
- identifying an unknown metal from determination of its molar mass
- Avogadro’s number
- Freezing point depression
- Kinetics of reactions of the ferroin complex
- Equilibrium Studies of the Iron(III) Thiocyanate reaction

Contribution to the professional component

100% Math and Basic Science

Course number, name	**CHEN 1211 General Chemistry for Engineers**
Credits and contact hours	4-credits, three 50-min lectures per week and one 50-min recitation per week
Instructor(s)	Michael Shirts, Douglas Gin
Textbook, Other materials	McMurry and Fay, Chemistry 6th ed., Prentice-Hall, 2012. Sapling Learning Subscription, iClickers, Desire2Learn (D2L)
Course description	One-semester lecture and recitation course designed to meet the general chemistry requirement for engineering students. Topics include stoichiometry; thermodynamics; gases, liquids, and solids; equilibrium; acids and bases; bonding concepts; kinetics; reactions; and materials science. Examples and problems illustrate the application of chemistry to engineering sub-disciplines. Credit not granted for this course and CHEM 1113/1114, 1251, or 1351.
Prerequisite(s)	Prereqs., one year of high school chemistry or CHEM 1021 (min. grade C-) and high school algebra. Not recommended for students with grades below B- in CHEM 1021. Recommended co-req. CHEM 1211.
Required or elective	Required for all students in degree program

Course learning objectives

After completing the work in this course, students will be able to

- Provide meaningful and quantitative answers for the questions:
  - What is the nature of matter?
  - How can we predict the properties of matter, and how is the periodic table helpful?
  - What makes chemicals react, and why do reactions go in a particular direction?
  - How can we quantify changes in chemical reactions?
- Solve quantitative engineering problems more easily problem solving
- Better appreciate of the richness of chemistry and its influence on your life.

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Large
2. an ability to design and conduct experiments	None
3. an ability to analyze and interpret data	None
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic,	None

	environmental, social, political, ethical, health and safety, manufacturability, and sustainability	
	5. an ability to function on multi-disciplinary teams	None
	6. an ability to identify, formulate, and solve engineering problems	Medium
	7. an understanding of professional and ethical responsibility	None
	8. an ability to communicate effectively through writing and drawings	Small
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small
	11. a recognition of the need for, and an ability to engage in life-long learning	Small
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	**Large**
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Atomic Structure; Compounds, Balancing Equations; Yield, Limiting Reactants, Solutions; Percent Composition, Combustion Analysis Reactions in Aqueous Media; Bases; Redox Reactions Electron Configuration; Ionic Bonds; Lewis Dot Structures, Resonance, Formal Charge, Vsepr Valence Bond and Hybridization Intro to Thermochemistry; Hess's Law, Calculating Heats of Reaction; Entropy, Gibb's Free Energy, Gas Laws Dalton's Law, Kinetic Theory, Real Gases; Intermolecular Forces Phase Changes, Vapor Pressure; Solids, Phase Diagrams Reaction Rates and Orders, Initial Rates; Integrated Rate Laws, Half-Lives, Mechanisms; Rate Laws, Arrhenius Equation, Catalysis Equilibrium Constants; Equilibrium Concentrations, Le Chatelier Kinetics, Intro to Acids and Base Equilibria; pH, Weak Acid/Base Equilibria Percent Dissociation, Polyprotic Acids, Salts, Lewis Acids Neutralization, Common Ions, Buffers; Titrations, Solubility, Precipitation Entropy and Probability, Thermodynamics; Free Energy and Chemical Equilibrium.	
Contribution to the professional component	100% Math and Basic Science	

Course number, name	**CVEN 1317 Introduction to Civil Engineering**

Credits and contact hours	2-credits, two 50-min lectures per week
Instructor(s)	Prof. Angela R. Bielefeldt, PhD, PE
Textbook, Other materials	No textbook required Readings from: ASCE Civil Engineering Body of Knowledge for the 21st Century (2008), ASCE 2013 Report Card for America's Infrastructure, Envision Sustainable Infrastructure Rating System Guidance Manual, The ASCE Code of Ethics: Principles, Study, and Application (2011)
Course description	Surveys the broad subject of civil and environmental engineering and professional practice. Includes the subdisciplines of structures, water resources, geotechnics, transportation, environment, and construction. Discusses professional ethics, important skills for engineers, and the engineering design process as it fulfills multiple objectives.
Prerequisite(s)	None
Required or elective	Required for all students in degree program
Course learning objectives	1. describe what civil engineering is, what you may do as a civil engineer, and the skills required to be a civil engineer 2. understand the process to gain the skills required to be an engineer and successfully graduate with a degree in civil engineering from CU 3. explain the importance of professional licensure (PE) for civil engineers 4. apply the professional codes of engineering ethics to evaluate situations you may encounter in your career 5. define sustainability, describe its importance to engineering, and identify aspects of sustainability in civil engineering projects

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Small
	2. an ability to design and conduct experiments	None
	3. an ability to analyze and interpret data	None
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Small
	5. an ability to function on multi-disciplinary teams	Small
	6. an ability to identify, formulate, and solve engineering problems	None
	7. an understanding of professional and ethical responsibility	**Large**

	8. an ability to communicate effectively through writing and drawings	Small
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	None
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Overview of civil engineering, infrastructure, and sub-disciplines Sustainable design Ethics and professional licensure Design and teamwork Process to earn a civil engineering degree and build relevant skills	
Contribution to the professional component	90% Engineering Science 10% Engineering Design	
Prepared by:	Angela Bielefeldt, 8/11/2016	

Course number, name	**CVEN 2012 Introduction to Geomatics**
Credits and contact hours	3-credits 2 hours/week Lecture and 3 hours/week Lab
Instructor(s)	W. T. Pfeffer, PhD
Textbook, other materials	"Elementary Surveying: An Introduction to Geomatics", 14^{th} ed. (C.D. Ghilani and P.R. Wolf, Pearson, 2015) Lab manual and worksheets provided in class.
Course description	Presents basic techniques of land and construction surveying, including measurement of position, elevation, orientation and length of lines, area, volume, and layout calculations. Optical, GPS, and GIS equipment and methods are included.
Prerequisite(s):	APPM 1350 Calculus 1 or Equivalent
Required or Elective:	Required for Architectural (AREN) and Civil (CVEN)
Course learning objectives. Demonstrate proficiency in the following:	Measurement of angle and distance at survey-grade precision. Position calculation at survey-grade precision with GPS in RTK mode Collect, record and analyze spatial data from field exercises. Perform area calculations of closed polygon with linear, circular, or irregular boundary segments. Use mathematical, computational and computer aided design tools for solving engineering problems. Use spatial data to complete mapping and engineering projects . Show effective written, and graphical communication skills as an individual and in a group for completion of mapping projects. Demonstrate ability to engage in lifelong learning culminating in licensure as a PE and LS.

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	Medium
	3. an ability to analyze and interpret data	Large
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	None
	5. an ability to function on multi-disciplinary teams	Large

6. an ability to identify, formulate, and solve engineering problems	Large
7. an understanding of professional and ethical responsibility	Medium
8. an ability to communicate effectively through writing and drawings	Large
9. an ability to communicate effectively through oral presentations	None
10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small
11. a recognition of the need for, and an ability to engage in life-long learning	Medium
12. a knowledge of contemporary issues	Small
13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Large
14. an ability to explain basic concepts in management, business, public policy, and leadership	None

List of topics covered

1. History, purposes and applications of surveying
2. Spatial concepts: Position, orientation, vector position, vector interval.
3. Geodesy: Coordinate systems, horizontal and vertical references. Differences between optical and GPS references.
4. Measurements: Concepts of precision and resolution.
5. Optical Measurements: Horizontal and vertical angles, electronic distance measurements.
6. Astronomical measurements.
7. Traversing: Closure and distribution of error
8. Polygon and Area Computations
9. Leveling; Cross Sections and Volumes
10. GPS measurements
11. GPS theory of measurements
12. RTK vs. Static measurements
13. Mapping and cadastral surveys
14. Construction surveys
15. Monitoring surveys
16. Other technologies: photogrammetry, scanning, as available via demos etc.

Contribution to the professional component:	95% Engineering Science 5% Engineering Design
Person(s) who prepared this:	W. Tad Pfeffer

Course number, name	**CVEN 2121 Analytical Mechanics 1 (Statics)**	
Credits and contact hours	3-credits, three 50-min lectures per week	
Instructor(s)	Assist. Prof. Petros Sideris, PhD, E.I.T	
Textbook, Other materials	*Engineering Mechanics – Statics* by R. C. Hibbeler, 14th Edition, Prentice Hall/ Pearson. Supplemental notes provided by the instructor	
Course description	Application of mechanics to the study of static equilibrium of rigid and elastic bodies. Topics include composition and resolution of forces; moments and couples; equivalent force systems; free-body diagrams; equilibrium of particles and rigid bodies; forces in trusses and beams; frictional forces; first and second moments of area; moments and products of inertia	
Prerequisite(s)	PHYS 1110, APPM 2350	
Required or elective	Required for all students in degree program	
Course learning objectives	1) Calculate the resultant forces and moments in 2D and 3D systems. 2) Draw free-body diagrams for particles and rigid bodies. 3) Solve particle and rigid body problems using the principle of static equilibrium. 4) Analyze 2D trusses using methods of joints and methods of sections. 5) Calculate internal forces in a beam and plot axial-force, shear-force and bending-moment diagrams. 6) Calculate the location of the center of gravity and the centroid of a given shape/volume. 7) Calculate moment of inertia for an area/volume over a given rotational axis.	
Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	**Large**
	2. an ability to design and conduct experiments	None
	3. an ability to analyze and interpret data	None
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	None
	5. an ability to function on multi-disciplinary teams	None

	6. an ability to identify, formulate, and solve engineering problems	**Large**
	7. an understanding of professional and ethical responsibility	Small
	8. an ability to communicate effectively through writing and drawings	Medium
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Medium
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	1. Introduction (Concepts, Units, Calculations, Analysis Procedures) 2. Force Vectors 3. Equilibrium of a Particle 4. Systems of Forces and Moments 5. Equilibrium of a Rigid Body 6. Structural Analysis of Trusses 7. Internal Axial/Shear Forces and Moments 8. Centroids & Centers of Gravity 9. Moments of Inertia 10. Friction	
Contribution to the professional component	100% Engineering Science	
Prepared by:	Petros Sideris, 10/08/2016	

Course number, name	**CVEN 3111 Analytical Mechanics 2**
Credits and contact hours	2-credits, three 50-min lectures per week
Instructor(s)	Asst. Prof. Jeong-Hoon Song, PhD
Textbook, Other materials	Engineering Mechanics - Dynamics by R. C. Hibbeler, 14th Edition None
Course description	Studies the motion (kinematics) of particles and rigid bodies, and the forces that cause the motion (kinetics). Newton's laws as well as energy methods are used to study the motion of particles and rigid bodies in two and three dimensions.
Prerequisite(s)	CVEN 2121 (minimum grade C-), Co-requisite APPM 2360
Required or elective	Required for all CVEN students in degree program
Course learning objectives	1. describe kinematics of particles in rectilinear and curvilinear motions 2. understand kinetics of particle through force and acceleration relation 3. understand kinetics of particle through work and energy concept 4. understand kinetics of particle through impulse and momentum 5. describe kinematics of a rigid body for translational, rotational and relative motions

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Large
2. an ability to design and conduct experiments	None
3. an ability to analyze and interpret data	None
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Small
5. an ability to function on multi-disciplinary teams	None
6. an ability to identify, formulate, and solve engineering problems	Medium
7. an understanding of professional and ethical responsibility	None
8. an ability to communicate effectively through writing and drawings	Small
9. an ability to communicate effectively through oral presentations	None

	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
	11. a recognition of the need for, and an ability to engage in life-long learning	Small
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Medium
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Rectilinear and Curvilinear motion, Absolute dependent and relative motion analysis, Equation of motion, Principle of work and energy, Principle of linear impulse and linear momentum, Planar rigid body motion	
Contribution to the professional component	90% Engineering Science 10% Engineering Design	
Prepared by:	Jeong-Hoon Song, 11/08/2016	

Course number, name	**CVEN3161 Mechanics of Materials I**
Credits and contact hours	3-credits, three 50-min lectures per week
Instructor(s)	Prof.Yunping Xi, PhD, Full Professor
Textbook, Other materials	Roy R. Craig, Jr. (2000) "Mechanics of Materials", John Wiley & Sons, New York
Course description	Addresses concepts of stress and strain; material properties, axial loading, torsion, simple bending, and transverse shear; analysis of stress and strain; and deflections of beams. Includes selected experimental and computational laboratories.
Prerequisite(s)	CVEN 2121 Analytical Mechanics 1. CVEN 2360 Introduction to Differential Equations with Linear Algebra
Required or elective	Required for all students in degree program
Course learning objectives	1. The ability to find analytical solution of a single structural member under different loading conditions, such as tension, compression, torsion, and bending. The analytical solution includes selection of cross section and examination of safety of a structural member. 2. The ability to analyze stress and strain states and find the principal stresses and strains. 3. The ability to establish stress-strain relation of brittle and ductile materials based on hands-on experience of tensile, compressive, and torsional testing of various construction materials. 4. The ability to analyze test data and write laboratory reports.

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	Medium
	3. an ability to analyze and interpret data	Large
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Small
	5. an ability to function on multi-disciplinary teams	None
	6. an ability to identify, formulate, and solve engineering problems	Medium
	7. an understanding of professional and ethical responsibility	Small

	8. an ability to communicate effectively through writing and drawings	Large
	9. an ability to communicate effectively through oral presentations	Small
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Large
	14. an ability to explain basic concepts in management, business, public policy, and leadership	Small
List of topics covered		
Contribution to the professional component	80% Engineering Science 20% Engineering Design	
Prepared by:	Yunping Xi, 11/10/2016	

Course number, name	**CVEN 3227 Probability, Statistics and Decision for Civil Engineering**	
Credits and contact hours	3-credits, two 75-min lectures per week	
Instructor(s)	Prof. Ross Corotis, PhD, PE, NAE; Prof. Abbie Liel, PhD, PE	
Textbook, Other materials	Probability Concepts in Engineering, Alfredo Ang and Wilson Tang, Second Edition, Wiley	
Course description	Introduces uncertainty based analysis concepts and applications in the planning and design of civil engineering systems emphasizing probabilistic, statistics, and design concepts and methods.	
Prerequisite(s)	Restricted to juniors and seniors	
Required or elective	Required for all students in degree program	
Course learning objectives	Students will gain fundamental knowledge of the concepts, methods, principles and terms related to uncertainty-based applications in planning and analysis of civil engineering systems; Students will be able to identify when design situations must incorporate concepts of uncertainty; Students will be able to calculate factors appropriate for decision-making under uncertainty in civil engineering practice.	
Relationship of course to program outcomes	<u>Program Outcome</u>	<u>Emphasis</u>
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	Small
	3. an ability to analyze and interpret data	Medium
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	None
	5. an ability to function on multi-disciplinary teams	None
	6. an ability to identify, formulate, and solve engineering problems	Small
	7. an understanding of professional and ethical responsibility	None
	8. an ability to communicate effectively through writing and drawings	None
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small

	11. a recognition of the need for, and an ability to engage in life-long learning	None
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Small
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Random events Random variables Probability distributions Moments, including joint moments Statistical analysis Hypothesis testing and linear regression	
Contribution to the professional component	100% Engineering Science 0% Engineering Design	
Prepared by:	Abbie Liel, 10/31/16	

Course number, name	**CVEN 3246 Introduction to Construction**
Credits and contact hours	3-credits, two 75-min lectures per week
Instructor(s)	Prof. Matthew R. Hallowell, PhD
Textbook, Other materials	Knutson, K., Schexnayder, C., Fiori, C. and Mayo, R. (2004). "Construction management fundamentals 2nd edition" McGraw Hill, New York, NY.
Course description	Broad view of concerns, activities, and objectives of people involved in construction: the owner, architect/engineer, contractor, labor, and inspector. Interactive gaming situation relates these people to the construction contract, plans/specifications, estimates/bids, scheduling, law, and financial management. Students with a Business School Real Estate emphasis may be considered for this course.
Prerequisite(s)	None
Required or elective	Required for all students in degree program
Course learning objectives	1. Describe the roles of key project players 2. Select an appropriate project delivery method for a construction project 3. Estimate the cost of a basic structure or roadway 4. Calculate the equivalence of a series of economic investments 5. Schedule a series of construction tasks using the critical path method 6. Analyze a balance sheet 7. Identify the requisite elements of a contract 8. Identify and analyze project risks 9. Identify and assess hazards on construction projects

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	None
2. an ability to design and conduct experiments	None
3. an ability to analyze and interpret data	None
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Medium
5. an ability to function on multi-disciplinary teams	Small
6. an ability to identify, formulate, and solve engineering problems	None
7. an understanding of professional and ethical responsibility	Medium

	8. an ability to communicate effectively through writing and drawings	Small
	9. an ability to communicate effectively through oral presentations	Small
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Small
	12. a knowledge of contemporary issues	Medium
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	None
	14. an ability to explain basic concepts in management, business, public policy, and leadership	Medium
List of topics covered	Project contracts Project delivery strategies Introduction to basic risk analysis Project controls Engineering economics Productivity measurement Hazard recognition and construction safety	
Contribution to the professional component	90% Engineering Science 10% Engineering Design	
Prepared by:	Matthew Hallowell, 11/1/2016	

Course number, name	**CVEN 3256 Construction Equipment and Methods**
Credits and contact hours	3-credits, three 50-min lectures per week
Instructor(s)	Paul M. Goodrum, PhD, PE and Matthew R. Hallowell, PhD
Textbook, Other materials	Peurifoy, R., Schexnayder, C., Shapira, A., and Schmidt, R. (2010). Construction Planning, Equipment, and Methods. 8th Edition. McGraw-Hill. Readings regarding construction formwork design from: Nunnally, S. W., Construction Methods and Management, 6th Ed., Prentice-Hall, 2003. Additional Material & References will also be used.
Course description	Integrated study of construction equipment, methods, and economics. Topics include equipment productivity, equipment selection, and construction engineering design within economic constraints. Examples include earthmoving, concrete formwork, and temporary construction.
Prerequisite(s)	CVEN 3246 – Introduction to Construction Engineering
Required or elective	Elective and can be taken as a proficiency course in construction engineering and management
Course learning objectives	1. Understand the different measurements and assessment techniques of productivity 2. Understand how to estimate earthwork volumes 3. Understand how to estimate production rates of excavators, tractors, dozers, and scrapers 4. Understand how to determine safe lifting capacities of cranes 5. Understand how to estimate production rates of loaders and haulers 6. Understand the methodology and how to estimate production rates of compaction and finishing 7. Understand the methodology of rock excavation 8. Understand the methodology of concrete construction 9. Understand the methodology of timber construction 10. Understand the methodology of steel construction 11. Understand the design procedures of temporary support systems including formwork design, scaffolding, and shoring.

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	**Large**
	2. an ability to design and conduct experiments	None
	3. an ability to analyze and interpret data	Medium

	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	**Large**
	5. an ability to function on multi-disciplinary teams	Small
	6. an ability to identify, formulate, and solve engineering problems	Medium
	7. an understanding of professional and ethical responsibility	Medium
	8. an ability to communicate effectively through writing and drawings	Medium
	9. an ability to communicate effectively through oral presentations	Medium
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small
	11. a recognition of the need for, and an ability to engage in life-long learning	Small
	12. a knowledge of contemporary issues	Medium
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Medium
	14. an ability to explain basic concepts in management, business, public policy, and leadership	Medium
List of topics covered	1. Construction Productivity 2. Construction Modeling 3. Earthwork Fundamentals 4. Tractors, Dozers, and Rippers 5. Construction Equipment Economics 6. Scrapers and Excavators 7. Cranes and Heavy Lift Planning 8. Loaders and Haulers 9. Compaction and Finishing 10. Rock Excavation 11. Asphalt & Concrete Paving 12. Foundation Systems 13. Concrete Construction 14. Timber Construction 15. Steel Construction 16. Formwork Design	
Contribution to the professional component	70% Engineering Science 30% Engineering Design	
Prepared by	Paul Goodrum, 10/31/2016	

Course number, name	**CVEN 3313 Theoretical Fluid Mechanics**
Credits and contact hours	3 credits, two 75-min lectures plus one 50-minute recitation per week
Instructor(s)	Prof. John Crimaldi, PhD Prof. Hari Rajaram, PhD
Textbook, Other materials	*Fundamentals of Fluid Mechanics* (8th ed.) Gerhart, Gerhart, and Hochstein, John Wiley & Sons. Or *A Brief Introduction to Fluid Mechanics* (5th ed.) Young, Munson, Okiishi, Huebsch, John Wiley & Sons.
Course description	Basic principles of fluid mechanics. Covers fluid properties, hydrostatics, fluid flow concepts, including continuity, energy, momentum, dimensional analysis and similitude.
Prerequisite(s)	CVEN 2121 or GEEN 2851 or ASEN 2001 or MCEN 2023
Required or elective	Required for all students in degree program
Course learning objectives	1. Understand concepts of fluids properties, fluid statics, Bernoulli equation, kinematics, conservation of mass, momentum, and energy, and concepts of similitude and dimensional analysis. 2. Apply fluid mechanics concepts to the solution of common engineering problems. 3. Use a combination of writing, equations, and pictures to effectively communicate complex engineering concepts.

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	**Large**
2. an ability to design and conduct experiments	None
3. an ability to analyze and interpret data	Small
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Small
5. an ability to function on multi-disciplinary teams	Small

	6. an ability to identify, formulate, and solve engineering problems	**Large**
	7. an understanding of professional and ethical responsibility	Small
	8. an ability to communicate effectively through writing and drawings	**Large**
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	**Large**
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Review of Calculus in engineering problems Fluid Statics Bernoulli Equation Fluid Kinematics Conservation of Mass, Momentum and Energy Dimensional Analysis	
Contribution to the professional component	90% Engineering Science 10% Engineering Design	
Prepared by:	John Crimaldi, 10/31/2016	

Course number, name	**CVEN 3323 Hydraulic Engineering**
Credits and contact hours	3 credits, three 50-min lectures per week, plus four 50-min labs during the semester
Instructor(s)	Prof. Roseanna M. Neupauer, PhD, PE
Textbook, Other materials	Fundamentals of Hydraulic Engineering Systems, 5th edition, by R.J. Houghtalen, A.O. Akan, and N.H.C. Hwang, Pearson, 2017. ISBN-13: 978-0-13-429238-0; ISBN-10: 0-13-429238-3
Course description	Studies hydraulic engineering theory and applications. Topics include incompressible flow in conduits, pipe system analysis and design, open channel flow, flow measurement, analysis and design of hydraulic machinery.
Prerequisite(s)	Requires prerequisite course of CVEN 3313 or MCEN 3021 or GEEN 3853 or AREN 2120 (all minimum grade C-).
Required or elective	Required for all students in degree program
Course learning objectives	1. Analyze flow in pipe systems and open channels using conservation of mass, momentum, and energy. 2. Route flows through hydraulic structures. 3. Observe and analyze features related to flow through hydraulic systems. 4. Design water distribution systems. 5. Use hydraulic engineering software.

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	**Large**
2. an ability to design and conduct experiments	**Large**
3. an ability to analyze and interpret data	**Large**
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	**Large**
5. an ability to function on multi-disciplinary teams	Medium
6. an ability to identify, formulate, and solve engineering problems	**Large**
7. an understanding of professional and ethical responsibility	Small
8. an ability to communicate effectively through writing and drawings	Small
9. an ability to communicate effectively through oral presentations	None

	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	**Large**
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Fluid properties Hydrostatic pressure and hydrostatic forces Conservation of mass, momentum, and energy Flow in pipes and pipe networks Water distribution system design Centrifugal pumps, pump selection, pump operating conditions Flow in open channels, uniform flow, specific energy, gradually-varied flow Hydraulic structures – weir, flumes, hydraulic jumps	
Contribution to the professional component	Engineering science 50% Engineering design 50%	
Prepared by:	Roseanna Neupauer, 10/31/2016	

Course number, name	**CVEN3414 Fundamentals of Environmental Engineering**
Credits and contact hours	3-credits, three 50-min lectures per week
Instructor(s)	Christopher J. Corwin, PhD, PE
Textbook, Other materials	Introduction to Environmental Engineering by C. David Cooper. 2015 Waveland Press.
Course description	Emphasizes chemical, ecological, and hydrological fundamentals and importance of mass and energy balances in solving environmental engineering problems related to water quality, water and wastewater treatment, air pollution, solid and hazardous waste management, sustainability, and risk assessment
Prerequisite(s)	CHEN 1211 and CHEM 1211 (or CHEM 1113 and CHEM 1114 or CHEM 1251 or CHEM 1351) and APPM 1360 (or MATH 2300; all min grade C-).
Required or elective	Required for all students in CVEN and EVEN degree programs
Course learning objectives	1. Understand the role of the environmental engineer in the protection of public health and the environment. 2. Explain the importance of and perform basic calculations in the major sub disciplines of environmental engineering: drinking water treatment, wastewater treatment, air pollution, solid and hazardous waste. 3. Prepare for the Fundamentals of Engineering (FE) exam.

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Large
2. an ability to design and conduct experiments	None
3. an ability to analyze and interpret data	None
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Small
5. an ability to function on multi-disciplinary teams	Small
6. an ability to identify, formulate, and solve engineering problems	Large
7. an understanding of professional and ethical responsibility	Small
8. an ability to communicate effectively through writing and drawings	Small

	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Large
	11. a recognition of the need for, and an ability to engage in life-long learning	Large
	12. a knowledge of contemporary issues	Large
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Medium
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Environmental regulations and population modeling Risk assessment Drinking water treatment BOD and Streeter-Phelps Wastewater treatment Air pollution control Solid waste management Hazardous waste management and remediation Sustainability and engineering for developing communities	
Contribution to the professional component	90% Engineering Science 10% Engineering Design	
Prepared by:	Chris Corwin, 9/4/2016	

Course number, name	**CVEN3424 Water and Wastewater Treatment**
Credits and contact hours	3-credits, three 50-min lectures per week
Instructor(s)	Christopher J. Corwin, PhD, PE
Textbook, Other materials	Water and Wastewater Engineering: Design Principles and Practice by Mackenzie L. Davis, McGraw-Hill Publishing, 2011
Course description	Introduces design and operation of facilities for treatment of municipal water supplies and wastewater. Provides an engineering application of physical, chemical, and biological unit processes and operations for removal of impurities and pollutants. Involves an integrated design of whole treatment systems combining process elements.
Prerequisite(s)	CVEN3414 (minimum grade C-)
Required or elective	Proficiency elective for students in CVEN Design technical elective for students in EVEN
Course learning objectives	1. Design common water and wastewater unit processes. Primarily those practiced in the US including legacy processes (processes that are no longer designed, but may still be used at existing plants). 2. Understand the underlying theory of how each physical, chemical, or biological unit process works. 3. Work as a team to design an integrated treatment plant where the unit processes must work together.

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	Small
	3. an ability to analyze and interpret data	Small
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Large
	5. an ability to function on multi-disciplinary teams	Medium
	6. an ability to identify, formulate, and solve engineering problems	Large
	7. an understanding of professional and ethical responsibility	Small
	8. an ability to communicate effectively through writing and drawings	Small
	9. an ability to communicate effectively through oral presentations	None

	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Medium
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Medium
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Water and wastewater regulations Coagulation and mixing Flocculation Sedimentation Filtration Disinfection Activated sludge Nutrient removal Attached growth systems Natural Treatment systems Advanced treatment: softening, packed tower aeration, advanced oxidation, activated carbon, high pressure membranes	
Contribution to the professional component	50% Engineering Science 50% Engineering Design	
Prepared by:	Chris Corwin, 9/4/2016	

Course number, name	**CVEN 3525 Structural Analysis**
Credits and contact hours	3-credits, two 75-min lectures per week
Instructor(s)	Prof. Victor Saouma, PhD
Textbook, Other materials	Hibbeler R.C., *Structural Analysis*, Prentice Hall, 9th ed. Various Handouts, papers.
Course description	This introductory course will provide the technical foundation to properly understand the analysis of statically determinate (simple) and indeterminate (complex) structures such as cables, trusses, frames, arches. Whereas emphasis will be on 2D structures, students will also be exposed to some 3D cases. Techniques of analysis include flexibility (hand calculation) and stiffness (computer based) methods. They will also be exposed to a widely used commercial program for the analysis of structure, and will be encouraged to program in Matlab and use Mathcad for their assignments. There will be at least one presentation by a Structural Engineer who will discuss the challenges of the profession.
Prerequisite(s)	Cven 3161
Required or elective	prerequisite to CVEN-4545 (Steel Design), CVEN-4555 (Reinforced Concrete Design), CVEN-4525 Matrix Analysis
Course learning objectives	Acquire abilities to 1. Apply knowledge of mathematics, science, and engineering 2. Identify, formulate, and solve engineering problems. 3. Communicate effectively through writing and drawings 4. Use the techniques, skills, and modern engineering tools necessary for engineering practice

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	None
	3. an ability to analyze and interpret data	None
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Small
	5. an ability to function on multi-disciplinary teams	None

	6. an ability to identify, formulate, and solve engineering problems	**Large**
	7. an understanding of professional and ethical responsibility	None
	8. an ability to communicate effectively through writing and drawings	Small
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	None
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	**Large**
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Analysis of statically indeterminate 2D and 3D structures; Flexibility method. Stiffness method. Curv ed members.	
Contribution to the professional component	90% Engineering Science 10% Engineering Design	
Prepared by:	Victor Saouma, 10/31/2016	

Course number, name	**CVEN 3698 Engineering Geology**
Credits and contact hours	3-credits, three 50-min lectures per week, one 50-min lab per week
Instructor(s)	Prof. Bernard Amadei, PhD
Textbook, Other materials	No textbook required Course notes can be downloaded from the course web site. Multiple readings are assigned for each class
Course description	Highlights the role of geology in engineering minerals; rocks; surficial deposits; rocks and soils as engineering materials; distribution of rocks at and below the surface; hydrologic influences; geologic exploration of engineering sites; mapping; and geology of underground excavations, slopes, reservoirs, and dam sites.
Prerequisite(s)	Requires a prerequisite or co-requisite course of CVEN 2121 or GEEN 2851 or ASEN 2001 or MCEN 2023 and APPM 2350 or MATH 2400 (all minimum grade C-). Restricted to College of Engineering majors only.
Required or elective	Science elective
Course learning objectives	From course introductory notes: The main objective in CVEN 3698 is to teach engineering students how to *appreciate* and *identify* geologic features that could have short and long-term consequences to the overall performance of various engineering structures and projects that they might encounter in their engineering careers. Students are exposed to fundamentals of geology and to various case studies were geology has played a critical role in rock or soil-structure interactions.

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Medium
2. an ability to design and conduct experiments	Small
3. an ability to analyze and interpret data	Medium
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Medium
5. an ability to function on multi-disciplinary teams	Large
6. an ability to identify, formulate, and solve engineering problems	Medium
7. an understanding of professional and ethical responsibility	Medium

	8. an ability to communicate effectively through writing and drawings	Large
	9. an ability to communicate effectively through oral presentations	Large
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Medium
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Small
	14. an ability to explain basic concepts in management, business, public policy, and leadership	Small
List of topics covered	Engineering geology as an interdisciplinary field Planet Earth and its population Geologic hazards and resilience to hazards Minerals and their engineering properties *Igneous Rocks*: geologic classification Engineering properties of plutonic rocks Engineering properties of volcanic rocks *Sedimentary Rocks*: geologic classification Engineering properties of shales, sandstones, etc. Engineering properties of soluble rocks *Metamorphic Rocks*: geologic classification Engineering properties of metamorphic rocks Fundamentals of structural geology Distribution of rocks at and below the surface Processes, soils and soil properties Exploration of an engineering site Computational engineering geology Topographic and geological maps for engineers Geophysical methods Stereographic projection (if time permits)	
Contribution to the professional component	90% Basic and Engineering Science 10% Engineering Design	
Prepared by:	Bernard Amadei, 9/19/2016	

Course number, name	**CVEN 3708 Geotechnical Engineering I**
Credits and contact hours	3-credits, two 50-min lectures in weeks with labs, otherwise 3 lectures a week
Instructor(s)	Prof. Ronald Pak, PhD
Textbook, Other materials	Das and Sobhan, Principles of Geotechnical Engineering, 8th edition, Cengage J.P. Bardet, Experimental Soil Mechanics, Prentice Hall
Course description	Basic engineering characteristics of geological materials; soil and rock classifications; physical, mechanical, and hydraulic properties of geologic materials; the effective stress principle; soil and rock improvement; seepage analysis; stress distribution; and consolidation and settlement analyses.
Prerequisite(s)	CVEN 3161 Mechanics of Materials (CVEN 3698 Engineering Geology recommended)
Required or elective	Required in degree program
Course learning objectives	• To introduce the terminology, basic principles and theories, analytical methods and laboratory techniques in soil mechanics for geotechnical and foundation engineering. • Be able to perform standard geotechnical engineering tests and analysis

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Large
2. an ability to design and conduct experiments	Large
3. an ability to analyze and interpret data	Large
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Small
5. an ability to function on multi-disciplinary teams	Medium
6. an ability to identify, formulate, and solve engineering problems	Medium
7. an understanding of professional and ethical responsibility	Small
8. an ability to communicate effectively through writing and drawings	Small
9. an ability to communicate effectively through oral presentations	None

	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
	11. a recognition of the need for, and an ability to engage in life-long learning	Small
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Large
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	• Soil origin, grain size distribution and geotechnical engineering terminologies • Weight-volume relation, soil plasticity and structures • Soil classifications and soil compaction • Permeability and seepage theory • Insitu stresses, effective stress principle and stresses in soil mass • Compressibility of soil, soil consolidation and settlement	
Contribution to the professional component	90% Engineering Science 10% Engineering Design	
Prepared by:	R. Pak	

Course alpha, number, title	**CVEN 3718 – Geotechnical Engineering 2**
Credits and contact hours	Total Credits: 3 *Lecture/Recitation/Discussion Hours: 2 @ 50-min/week, Lab 2 hrs/week*
Instructor	Dobroslav Znidarcic or Ronald Pak
Textbook(s) and/or other required material	D.P. Coduto: Geotechnical Engineering: Principles and Practices, Prentice Hall, 2nd ed. J.P. Bardet: Experimental Soil Mechanics, Prentice Hall Other similar texts available in the library for supplemental reading and problem solving
Course description	Discusses shear strength, bearing capacity, lateral earth pressures and slope stability. Analyzes and looks at the design of shallow and deep foundations, retaining walls, and other earth and rock structures. Selected experimental and computational laboratories
Required or elective	Elected by most CVEN students to satisfy proficiency requirements
Prerequisite(s)	CVEN 3708 Geotechnical Engineering 1
Course learning objectives	o Ability to understand the concept of shear strength and failure conditions in soils o Ability to determine shear strength parameters o Ability to perform and apply stress analysis in geotechnical engineering o Ability to evaluate slope stability o Ability to design soil retaining structures o Ability to design foundations

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Large
2. an ability to design and conduct experiments	Medium
3. an ability to analyze and interpret data	Medium
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Small
5. an ability to function on multi-disciplinary teams	Small
6. an ability to identify, formulate, and solve engineering problems	Large
7. an understanding of professional and ethical responsibility	Medium
8. an ability to communicate effectively through writing and drawings	Medium
9. an ability to communicate effectively through oral presentations	None

	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
	11. a recognition of the need for, and an ability to engage in life-long learning	Small
	12. a knowledge of contemporary issues	None
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Medium
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
Topics covered	• Shear Failure, Mohr-Coulomb Failure Criterion • Slope Stability • Lateral Earth Pressure • Design of Retaining Structures • Bearing Capacity • Design of Shallow and Deep Foundations	
Contribution to the professional component	60% Engineering Science 40% Engineering Design	
Person(s) who prepared this description	Dobroslav Znidarcic	
Date of Preparation	2/5/2017	

Course number, name	**CVEN 4333 Engineering Hydrology**
Class/Lab schedule	Total Credits: 3 *Lecture Hours: 3/week*
Instructors	Joseph Kasprzyk or Ben Livneh
Textbook, Other materials	Mays, Water Resources Engineering 2nd Edition
Course description	Water is ubiquitous and forms the foundation for life on earth. It transports energy throughout the atmosphere regulating climate and climate change, carves and erodes the surface of the earth, and serves as one of our most precious and limited natural resources. The objective of this course is to provide an understanding of the complexity and importance of the movement, distribution, and quality of water, while emphasizing an application to engineering practices. The course studies engineering applications of principles of hydrology, including hydrologic cycle, rainfall and runoff, groundwater, storm frequency and duration studies, stream hydrography, flood frequency, and flood routing.
Prerequisite(s)	Prerequisite CVEN 3313 Fluid Mechanics; Co-requisite CVEN 3227
Required or elective	Required for some CVEN students to satisfy proficiency requirements.
Course learning objectives	o Describe and quantify major processes within the hydrologic cycle including precipitation, infiltration, evapotranspiration, and runoff o Calculate unit hydrograph, flood frequency analysis, routing, and other activities that contribute to water resources engineering o Conduct computer modeling experiments with popular rainfall-runoff modeling simulation models and spreadsheet software and understand the limitations and implications of the models o Appreciate and explain the impact that hydrology and water resources has on everyday life

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	Small
	3. an ability to analyze and interpret data	Large
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Medium
	5. an ability to function on multi-disciplinary teams	None

	6. an ability to identify, formulate, and solve engineering problems	Large
	7. an understanding of professional and ethical responsibility	Small
	8. an ability to communicate effectively through writing and drawings	Medium
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Large
	12. a knowledge of contemporary issues	Medium
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Large
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
Topics covered	• Applied statistics and probability • Return periods and flood frequency analysis • Watersheds and mass balance calculations • Precipitation, evapotranspiration, infiltration • Surface runoff using rational method and SCS method • Unit hydrographs • Streamflow routing • Computer modeling using HEC-HMS and HEC-RAS • Groundwater • Hydro-ecology • Climate change	
Contribution	90% Engineering Science 10% Engineering Design	
Prepared by	Joseph Kasprzyk and Ben Livneh	
Date	9/29/2016	

Course number, name	**CVEN 4545 Steel Design**
Credits and contact hours	3 credits, 2 – 75min lectures per week
Instructor(s)	George Hearn, PE
Textbook, Other materials	AISC Steel Construction Manual, 14th ed. Course notes and design project writeup posted at course website
Course description	Applies basic principles of structural engineering and mechanics to design of steel structures; design of tension members, columns, beams, open-web joists, steel decks, bolts, bolted connections, welding processes, and welded connections.
Prerequisite(s)	CVEN 3525
Required or elective	Elective – CVEN proficiency course
Course learning objectives	Ability to design steel decks, beams, columns and braces for low rise buildings

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Small
2. an ability to design and conduct experiments	None
3. an ability to analyze and interpret data	None
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Large
5. an ability to function on multi-disciplinary teams	None
6. an ability to identify, formulate, and solve engineering problems	None
7. an understanding of professional and ethical responsibility	Small
8. an ability to communicate effectively through writing and drawings	None
9. an ability to communicate effectively through oral presentations	None
10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
11. a recognition of the need for, and an ability to engage in life-long learning	Small

	12. a knowledge of contemporary issues	None
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	None
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Steel material, properties Rolled shapes Steel deck, Concrete slabs in steel deck Steel bar joists Steel beams, moment strength, shear strength Steel columns Bolted steel connections Welded steel connections	
Contribution to the professional component	10% Engineering Science 90% Engineering Design	
Prepared by:	George Hearn 10/31/2016	

Course number, name	**CVEN 4555 Reinforced Concrete Design**
Credits and contact hours	3 credits, 2 – 75min lectures per week
Instructor(s)	George Hearn, PE
Textbook, Other materials	ACI318-14 Building Code Requirements for Structural Concrete Course notes and design project writeup posted at course website
Course description	Applies basic principles of structural engineering and mechanics to the design of reinforced concrete structures, including design of beams, columns, slabs, and footings; continuous beams and frames; cast-in-place buildings.
Prerequisite(s)	CVEN 3525
Required or elective	Elective – CVEN proficiency course
Course learning objectives	Ability to design non-prestressed, reinforced concrete slabs, joists, beams and columns for low-rise buildings.

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Small
2. an ability to design and conduct experiments	None
3. an ability to analyze and interpret data	None
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Large
5. an ability to function on multi-disciplinary teams	None
6. an ability to identify, formulate, and solve engineering problems	None
7. an understanding of professional and ethical responsibility	Small
8. an ability to communicate effectively through writing and drawings	None
9. an ability to communicate effectively through oral presentations	None
10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
11. a recognition of the need for, and an ability to engage in life-long learning	Small

	12. a knowledge of contemporary issues	None
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	None
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Concrete materials, concrete reinforcing steel One-way slabs: moment strength, shear strength, reinforcement limits, reinforcement detailing. Beams, Tee beams: moment strength, shear strength, reinforcement limits, reinforcement detailing. Short columns: Axial load strength, moment strength, interaction of compression and bending, reinforcement limits, reinforcement detailing Slender columns: moment magnification, interaction of compression and bending	
Contribution to the professional component	10% Engineering Science 90% Engineering Design	
Prepared by:	George Hearn 10/31/2016	

Course number, name	**CVEN 4897 Professional Issues in Civil Engineering**
Credits and contact hours	2-credits, one 100-min lecture per week
Instructor(s)	Prof. Angela R. Bielefeldt, PhD, PE
Textbook, Other materials	No textbook required Readings from: ASCE Civil Engineering Body of Knowledge for the 21st Century (2008); NCEES Fundamentals of Engineering Exam Specifications; Ressler SJ, To Raise the Bar or Not: Addressing the Opposition, American Society for Engineering Education Conference & Exposition Proceedings (2012); The ASCE Code of Ethics: Principles, Study, and Application (2011); McGee RW, An economic and ethical analysis of the Katrina disaster, International Journal of Social Economics, 35 (7), 546-567 (2008); Envision Sustainable Infrastructure Rating System Guidance Manual; Toor S-U-R and Ofori G, Leadership versus Management: How they are different, and why, Leadership & Management in Engineering, p. 61-71, (Apr. 2008); Miller JB, The Civil Engineer in Society, Journal of Professional Issues in Engineering Education & Practice, p. 161-162 (Oct. 2002); Volker M, Business Basics for Engineers, http://www.sfu.ca/~mvolker/biz/
Course description	Educates students about the knowledge and skills required for professional civil engineers. Students learn about the path to a professional license, prepare for the FE exam, analyze a situation involving multiple conflicting ethical interests, identify aspects of sustainability in civil engineering projects, and understand the role of project management, public policy, business and public administration, and leadership in civil engineering.
Prerequisite(s)	None
Required or elective	Required for all students in degree program
Course learning objectives	1. explain the importance of professional licensure and the path to become a licensed PE 2. analyze a situation involving multiple conflicting professional and ethical interest to determine an appropriate course of action 3. identify aspects of sustainability in civil engineering projects, and the ethical requirements to strive for sustainable development in civil engineering projects 4. explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and explain the impact of engineering solutions on the economy, environment, political landscape, and society 5. explain the key aspects of project management 6. define and explain leadership, the role of a leader, and leadership principles and attitudes

	7. describe and discuss key information related to public policy that is relevant to civil engineering 8. explain key concepts and processes used in business and public administration	
Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Small
	2. an ability to design and conduct experiments	None
	3. an ability to analyze and interpret data	None
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints…	None
	5. an ability to function on multi-disciplinary teams	None
	6. an ability to identify, formulate, and solve engineering problems	None
	7. an understanding of professional and ethical responsibility	**Large**
	8. an ability to communicate effectively through writing and drawings	Small
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Medium
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	None
	14. an ability to explain basic concepts in management, business, public policy, and leadership	Large
List of topics covered	Path to PE, FE practice, FE review Sustainable design Ethics and contemporary issues Sustainable design Project management vs. leadership Public policy Business and public administration	
Contribution to the professional component	100% Engineering Professional Skills	
Prepared by:	Angela Bielefeldt, 8/11/2016	

Course number, name	**CVEN 4899 Civil Engineering Senior Design**
Credits and contact hours	4-credits, two 1.5-hour lectures per week
Instructor(s)	Senior Instructor Matt Morris, P.E. [Lead & Construction Engineering]; Professor Rajagopalan Balaji, PhD [Water Resources]; Assistant Professor Petros Sideris, PhD [Structures]; Assistant Professor Shideh Dashti [Geotech]
Textbook, Other materials	No textbook required Pertinent codes, design standards and regulations pertaining to the specific semester project. Existing drawings, specifications, reports, surveys and studies.
Course description	Provides a simulated real world design and construction planning experience where teams integrate across multiple civil engineering sub-disciplines to create a solution that satisfies multiple constraints, including design, client requirements, budget, schedule, technical, regulatory, and societal. Final deliverables include: detailed design drawings, specifications, cost estimate, project schedule, construction plans, oral and written presentation.
Prerequisite(s)	Restricted to students with 87-180 credits (Senior) Civil (CVEN) or General (GEEN) engineering majors only.
Required or elective	Required for all students in degree program
Course learning objectives	• Integrate the technical sub-disciplines of structural, geotechnical, water resources and construction to create a professional-level solution to the assigned project problem. • Gather relevant data, understand client needs, identify constraints, and identify and use applicable regulations, codes and standards. • Create feasible alternative designs and value engineering analysis. • Prepare increasingly detailed designs and construction planning that satisfies the Owner's goals and project's constraints while also conforming to relevant codes and regulations. • Prepare design documentation including design rationale and intent, design details and integrated project planning, scheduling and construction cost analysis to support each design stage • Complete primary components of contract documents for client as well as basic specifications. • Present ideas, concepts and designs to the client from the perspective of an engineering firm attempting to win a design-build contract. • Work in multi-disciplinary teams and in interdisciplinary formats as appropriate during different phases of the assignment.

<u>Program Outcome</u> <u>Emphasis</u>

Relationship of course to program outcomes	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	Small
	3. an ability to analyze and interpret data	Large
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Large
	5. an ability to function on multi-disciplinary teams	Large
	6. an ability to identify, formulate, and solve engineering problems	Large
	7. an understanding of professional and ethical responsibility	Medium
	8. an ability to communicate effectively through writing and drawings	Large
	9. an ability to communicate effectively through oral presentations	Large
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
	11. a recognition of the need for, and an ability to engage in life-long learning	Large
	12. a knowledge of contemporary issues	Medium
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Large
	14. an ability to explain basic concepts in management, business, public policy, and leadership	Medium
List of topics covered	Multiple professor-led and guest speaker classes devoted toward project-specific structural, water, geotech and construction topics Written and oral presentation skills Professional licensure Business development Leadership & Management Global engineering, environmental and societal issues Industry outlook, personal & professional development Infrastructure	

Contribution to the professional component: 90% Engineering Design; 10% Engineering Science

Prepared by: Matt Morris, 10/31/2016

Course number, name	**GEEN 1400 First-Year Engineering Projects**
Credits and contact hours	3-credits, one 50-min lecture per week, two 2-hr labs per week
Instructor(s)	Derek Reamon (course coordinator); various instructors per section
Textbook, Other materials	Introductory Engineering Design: A Projects-Based Approach. Third Edition. (Optional) Online textbook: https://itll.colorado.edu/courses_workshops/geen_1400/resources/textbook/
Course description	First-year students solve real engineering design problems in interdisciplinary teams. Design projects vary by section. Curriculum focuses on iterative design process, teamwork and team dynamics, supporting design with testing and analysis, and technical writing. Completed projects are exhibited at an end-of-semester design expo. Students responsible for contributing towards their design project budget and poster costs, and purchasing safety glasses (approximately $75).
Prerequisite(s)	None.
Required or elective	Recommended for all students in degree program; students may alternatively take a basic engineering elective course
Course learning objectives	• Introduction to engineering as a career. Conceptually understand engineering as a field, and its difference from, and interaction with, science and math; appreciates how engineering pervades society and drives societal change; gains insight into the various engineering disciplines; considers engineering as a possible career. • Introduction to engineering methodology. Understand the role of analysis in design; familiar with appropriate computer software; solves engineering problems; effectively uses hand tools; effectively uses manufacturing processes. • Open-ended hands-on design experiences. Familiar with iterative design process; able to define functional requirements and client specifications, if appropriate; generates alternative design concepts; applies structured decision analysis; works within constraints (e.g., budgets); makes environmental and universal design considerations, as appropriate. • Development of communication skills (oral, written, team, advisor). Develops a relationship with an engineering faculty member; develops technical writing, oral presentation and client communication skills as appropriate for project. • Teamwork skills. Learns and practices effective teamwork skills (e.g., multi-tasking, group leadership, brainstorming, information gathering, team-based decision-making); learns to rely on other team members to give and receive help; demonstrates dedication and commitment to team objectives; and increased understanding of

	diversity; practices realistic self-evaluation as a team member; learns and practices conflict resolution; develops relationships with other engineering students that extend beyond FYEP.	
Relationship of course to program outcomes	<u>Program Outcome</u>	<u>Emphasis</u>
	1. an ability to apply knowledge of mathematics, science, and engineering	Small
	2. an ability to design and conduct experiments	None
	3. an ability to analyze and interpret data	None
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Large
	5. an ability to function on multi-disciplinary teams	Large
	6. an ability to identify, formulate, and solve engineering problems	Medium
	7. an understanding of professional and ethical responsibility	None
	8. an ability to communicate effectively through writing and drawings	Small
	9. an ability to communicate effectively through oral presentations	Small
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Small
	11. a recognition of the need for, and an ability to engage in life-long learning	Small
	12. a knowledge of contemporary issues	Small
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Large
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Social styles; team dynamics exercises; introductory project; ethics Main project: deliverables, including prototype demonstration, preliminary design review, critical design review and demonstration of final hardware. Workshops: inc. shop safety, CAD, circuit design/soldering Design expo: students demonstrate final projects and display poster; engineers from local industry serve as judges.	
Contribution	100% Engineering Design	

Course number, name	**PHYS 1110 General Physics I**
Credits and contact hours	4-credits, three 50-min lectures per week, one 50-min recitation per week
Instructor(s)	Varies; spring: Daniel Bolton and Ed Kinney
Textbook, Other materials	Essential University Physics, Volume 1, 3rd Edition. Richard Wolfson, Addison-Wesley. Tutorials in Introductory Physics, McDermott et al., Custom CU edition. Access to online homework system MasteringPhysics Access to online pre-lecture videos on FlipItPhysics An iClicker that is registered on D2L.
Course description	First semester of three-semester sequence for science and engineering students. Covers kinematics, dynamics, momentum of particles and rigid bodies, work and energy, gravitation, simple harmonic motion and introduction to thermodynamics.
Prerequisite(s)	Prereq or Coreq: APPM 1345 or APPM 1350 or MATH 1300 or MATH 1310.
Required or elective	Required
Course learning objectives	Students should understand that learning does not mean memorizing answers to specific questions; instead, learning means understanding general strategies, and developing robust internal models which permit one to recognize which strategy is appropriate and how to apply it. In this course, there are two broad strategies that students should master. • Newton's Laws. Given appropriate initial conditions of a classical mechanical system, the student should be able to compute the subsequent motion by applying Newton's Laws. This requires mastery of concepts in kinematics and dynamics, and knowing how to apply Newton's Laws in for both translational and rotational motions. • Conservation Laws. By comparing a known initial state of a system and a partly-known final state, the student should be able to apply one of the conservation laws (energy, momentum, or angular momentum) to determine the final state of the system.

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	None
	3. an ability to analyze and interpret data	None
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic,	None

	environmental, social, political, ethical, health and safety, manufacturability, and sustainability	
	5. an ability to function on multi-disciplinary teams	None
	6. an ability to identify, formulate, and solve engineering problems	None
	7. an understanding of professional and ethical responsibility	None
	8. an ability to communicate effectively through writing and drawings	None
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
	11. a recognition of the need for, and an ability to engage in life-long learning	None
	12. a knowledge of contemporary issues	None
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	None
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Vector Math and Kinematics: velocity and acceleration in 1D and 2D. Newtonian mechanics • Newton's Laws • Work and Energy • Gravitation • Linear Momentum and collisions • Rotational motion and angular momentum • Simple Harmonic Motion Fluids. Introduction to thermodynamics: Calorimetry, changes of phase; heat transport; 1st Law of Thermodynamics, 2nd Law of Thermodynamics.	
Contribution	100% Math and Basic Science	

Course number, name	**PHYS 1120 General Physics II**
Credits and contact hours	4-credits, three 50-min lectures per week, one 50-min recitation per week
Instructor(s)	Dr. Michael Dubson, course coordinator. Individual instructors vary.
Textbook, Other materials	Tutorials in Introductory Physics, McDermott et al., Custom CU edition. Access to online homework system MasteringPhysics Access to online pre-lecture videos on FlipItPhysics An iClicker that is registered on D2L.
Course description	Second semester of three-semester introductory sequence for science and engineering students. Covers electricity and magnetism, wave motion, and optics. Normally is taken concurrently with PHYS 1140.
Prerequisite(s)	Prereq PHYS 1110 and prereq or coreq APPM 1360 or MATH 2300.
Required or elective	Required
Course learning objectives	Students should understand that learning does not mean memorizing answers to specific questions; instead, learning means understanding general strategies, and developing robust internal models which permit one to recognize which strategy is appropriate and how to apply it. In this course, the general strategy is application of Maxwell's equations. There are two broad categories for applications of Maxwell's equations: • Charges, currents, and fields. Given a known distribution of charges and/or currents, students should be able to compute the electric and magnetic fields. Similarly, given the fields, students should be able to compute the forces on and motion of charges. • Circuit analysis. Students should be able to understand and analyze simple DC and AC circuits containing batteries, resistors, capacitors, and inductors..

Relationship of course to program outcomes

Program Outcome	Emphasis
1. an ability to apply knowledge of mathematics, science, and engineering	Large
2. an ability to design and conduct experiments	None
3. an ability to analyze and interpret data	None
4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	None
5. an ability to function on multi-disciplinary teams	None
6. an ability to identify, formulate, and solve engineering problems	None

	7. an understanding of professional and ethical responsibility	None
	8. an ability to communicate effectively through writing and drawings	None
	9. an ability to communicate effectively through oral presentations	None
	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
	11. a recognition of the need for, and an ability to engage in life-long learning	None
	12. a knowledge of contemporary issues	None
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	None
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	Static Electric fields, Gauss's Law, Voltage and capacitance, DC Circuits, Magnetic , Fields: Biot-Savart Law and Ampere's Law , Faraday's Law, inductance, Electromagnetic waves and Maxwell's equations, Ray Optics, Wave optics and diffraction (time permitting)	
Contribution	100% Math and Basic Science	

Course number, name	**PHYS 1140 Experimental Physics I**
Credits and contact hours	1-credit, one 50-min lecture per week, one 2-hr lab per week
Instructor(s)	Heather Lewandowski, coordinator. Individual instructors vary.
Textbook, Other materials	An Introduction to Error Analysis, 2nd ed, John Taylor, University Science (1997). Optional. An iClicker that is registered on D2L.
Course description	Introduction to experimental physics through laboratory observations of a wide range of phenomena. Course covers experiments on physical measurements, linear and rotational mechanics, harmonic motion, wave motion, sound and heat, electricity and magnetism, optics, and electromagnetic waves with the mathematical analysis of physical errors associated with the experimental process.
Prerequisite(s)	Prereq or coreq PHYS 1120 (minimum grade C-).
Required or elective	Required
Course learning objectives	Students are trained and assessed in 3 broad skills. • Experience with a variety of simple experimental techniques, especially including working knowledge of an oscilloscope. • Ability to extract a computed quantity from measured data and to establish an appropriate error bar on the computed quantity. • Ability to prepare written report describing the measurements, analysis, and basic outcomes of the experiment.

Relationship of course to program outcomes	Program Outcome	Emphasis
	1. an ability to apply knowledge of mathematics, science, and engineering	Large
	2. an ability to design and conduct experiments	Large
	3. an ability to analyze and interpret data	Large
	4. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	None
	5. an ability to function on multi-disciplinary teams	None
	6. an ability to identify, formulate, and solve engineering problems	None
	7. an understanding of professional and ethical responsibility	None
	8. an ability to communicate effectively through writing and drawings	Medium
	9. an ability to communicate effectively through oral presentations	None

	10. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	None
	11. a recognition of the need for, and an ability to engage in life-long learning	None
	12. a knowledge of contemporary issues	None
	13. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	None
	14. an ability to explain basic concepts in management, business, public policy, and leadership	None
List of topics covered	A wide variety of experiments in mechanics, electricity & magnetism, and optics are made available so that the student has considerable freedom of choice in the investigation of special topics. Students are trained in the use of Mathematica software to perform data analysis and prepare lab reports. The material covered in the lecture includes the estimation of uncertainties, significant figures, mean values, the standard deviation, the standard deviation of the mean, comparison of measured and accepted values, random and systematic errors, propagation of errors, and the normal distribution.	
Contribution	100% Math and Basic Science	

Course number, name	**WRTG 3030 Writing on Science and Society**	
Credits and contact hours	3-credits, three 50-min lectures per week	
Instructor(s)	Instructors vary.	
Textbook, Other materials	Readings and course materials available on D2L; vary by section. The Purdue University OWL (online writing lab) They Say, I Say: The Moves that Matter in Academic Writing, Graff and Birkenstein, WW Norton & Co. Writing Science: How to Write Papers hat Get Cited and Proposals that Get Funded. Schimel, Oxford UP 2012 The Colorado State University Writing Center, which offers an array of writing & teaching resources: http://writing.colostate.edu/ College-level writing handbook The Colorado State University "WAC Clearinghouse," which supports scholarly exchange about communication across the curriculum: http://wac.colostate.edu/	
Course description	Through selected reading and writing assignments, students consider ethical and social ramifications of science policy and practice. Focuses on critical thinking, analytical writing, and oral presentation. Taught as a writing workshop, the course addresses communication with professional and non-technical audiences.	
Prerequisite(s)	Restricted to students with 57-180 credits.	
Required or elective	Required (or approved substitute)	
Course learning objectives	Critical Thinking and Its Written Application; The Writing Process; Rhetorical Situation; Mechanics and Style. Fulfills the course criteria given to all state institutions by the Colorado Commission on Higher Education. In other words, this writing class is not just about what your writing teacher here at CU thinks is important. It's about deepening your skills in rhetorical knowledge, writing processes, and language conventions so that you can write effectively for a variety of audiences in a variety of situations—both inside and outside the classroom.	
Relationship of course to program outcomes	Program Outcome	Emphasis
	8. an ability to communicate effectively through writing and drawings	Large
List of topics covered	Summary/Response; Resume/Cover Letter; Editorial Argument; Rhetorical Analysis; Research Issues and Approach; Final Project. A substantive inquiry into an issue or topic of the student's choice. The project will go through multiples stages of revision, and will reflect	

the conventions of an appropriate science, technical communication, or professional writing genre.

Evaluating Disciplinary Scientific Argument; Evaluating Popular Scientific Argument; Research in a Disciplinary Genre; Research “accommodation” in a Popular Genre.

Social & Professional Context; Rhetorical Knowledge; Best Practices for Revision; The Writing Process; The Concept of Genre and Science Writing for a Specialized Audience; Compiling Annotated Bibliography; Deliberative Discourse; Adopting the Ethos of Education not Debater; Defining Terms and Illustrating Claims; Developing Evidence; Making Clear Transitions; Revising for Brevity & Clarity; Anticipating & Answering Objections; Emphasizing Best Ideas; The Essay Form; Writing Introductions for Lay & Scientific Audiences; Paraphrase and Citation; How to Write Developmental, Results, Discussion, and Conclusion, Sections; Voice and Style.

Rhetorical essays including techniques of thesis-building, evidential support, organization, and rhetorical awareness; Research Proposals for funding agencies; Academic Articles including annotated bibliography & disciplinary Analysis.

Rhetorical Framework; Resumes and Professional Writing; Communicating Science; White Papers; Project Development & Science in the Public Sphere; Project Proposals and Ethics;
White Paper Presentations.

Contribution 100% Math and Basic Science

Appendix B – Faculty Vitae

Two page CVs for each of the civil engineering program faculty members are included below, listed in alphabetical order. These are followed by CEAE faculty in the building systems program, as these individuals generally have much lower contribution to the civil engineering program.

Bernard Amadei **Professor**

EDUCATION	PhD (Civil Eng.), University of California, Berkeley, U.S.A., 1982 MaSc (Civil Eng.), University of Toronto, Canada, 1979 Dipl. Eng./BS (Geol. Eng.), School of Applied Geology & Mining Eng., Nancy, France, 1977
ACADEMIC EXPERIENCE	University of Colorado Boulder, Dept. Civil, Environmental, and Architectural Engineering: Professor (1994-Present); Assoc. Prof (1989-1994), Assistant Prof. (1982-1989) University of Colorado Boulder, Mortenson Center in Engineering for Developing Communities, Director (2009-2012), co-Director (2015-Present) Visiting Professor, Technion University, Israel (2010-2014)
NON-ACADEMIC EXPERIENCE	U.S. Science Envoy to Pakistan and Nepal, U.S. Department of State (2013-14) Founding President, Engineers Without Borders – USA and co-Founder of Engineers Without Borders – International (2002-Present) Independent Consultant in International Development and Geological Engineering (1982-Present) Senior Engineer, J. F. T. Agapito and Associates, Inc., Grand Junction, Colorado (Jan-June, 1982)
PROFESSIONAL REGISTRATIONS	Registered in EU countries but not in US
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	US National Academy of Engineering National Academy of Construction American Society of Civil Engineers International Society for Rock Mechanics American Society of Mechanical Engineers American Rock Mechanics Association Institute of Electrical and Electronics Engineers American Society of Engineering Education
HONORS AND AWARDS	Five honorary doctoral degrees (UMass Lowell; Carroll College; Clarkson, Drexel, and Worcester Polytechnic Institute). 1984 Manuel Rocha Award, International Society for Rock Mechanics. 1992 Schlumberger Lecture Award, Int. Society for Rock Mechanics. 2002 Bank One Colorado Faculty Community Service Award 2005 Am. Association of Engineering Societies Norm Augustine Award 2005 Service Award for Professional Excellence from Rotary International 2006 General Palmer Award from ACEC, Colorado 2006 Ralph Coats Roe Medal, Am. Society of Mechanical Engineers 2007 Hoover Medal from ASCE, ASME, IEEE, AIME, and AIChE 2007 Heinz Foundation Award for the Environment (co-recipient) 2008 Drexel University College of Engineering's Engineer of the Year 2008 Golden Vector Award, Pan American Fed. of Eng. Assoc. (UPADI) 2008 Member of the US National Academy of Engineering 2008 Engineering News Record Award of Excellence 2009 Distinguished Member of the American Society of Civil Engineers 2013 Member of the National Academy of Construction 2015 Washington Award, The Western Society of Engineers 2015 American Society of Civil Engineers, (OPAL) (education) 2016 C. H. Dunn Award of the Construction Industry Institute

INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	**University of Colorado Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Personnel Committee Curriculum Committee (2013-2015) EWB-USA CU Boulder Chapter Advisor Mortenson Center in Engineering for Developing Communities Director. 2009 – 2012; co-Director: 2015-Present **University (non-CU) Service** Consultant to PeaceEng program at Drexel University Summer course development, Technion University **Non-University Service** • Member NAE Award Committee (2017-2018) • U.S. Science Envoy to Pakistan and Nepal, U.S. Dept. of State (2013-14) • Member, NAE/USIP Roundtable on Technology, Science, and Peace building (2011-present) • Member (and co-chair), Board of the PeaceTech laboratory (2014-present) • Member, NRC Committee on USAID Grand Challenges in International Development (2011-2013) • Member, NRC Committee on Increasing National Resilience to Hazards and Disasters (2010-2012) • Founding-President, Engineers Without Borders - USA (2001-present)
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	• *A Systems Approach to Modeling Community Development Projects*. Amadei, B., ISBN-13: 978-1-60650-518-2, Momentum Press, 2015. • *Engineering for Sustainable Human Development*, Amadei, B., ISBN 978-0-7844-1353-1, ASCE Press, Reston, VA, 2014. • “Disaster Resilience: A National Imperative”, contributing committee member, The National Academies Press, 2012. • “A Retrospective Approach to Assessing the Sustainability of the Grand Canal of China”, N. Tsung, R. Corotis, P. Chinowsky, and B. Amadei, *ASCE Journal of Structure and Infrastructure Engineering*, 9(4), pp. 297-316, 2013. • "Integrating sustainable development into a service learning engineering course”, Mintz et al., *ASCE Journal of Professional Issues in Engineering Education and Practice*, doi: 10.1061/ (ASCE) EI. 1943-5541.0000169, 2013. • “Engineering for developing communities at the University of Colorado Boulder: A ten-year retrospective,” R. Sandekian, P. Chinowsky, B. Amadei, *Int. J. Service Learning in Eng*., pp. 62-77, 2015.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Attended multiple conferences, workshops, and meetings during the past five years dealing with various aspects of system dynamic modeling, GIS, and science diplomacy.

Rajagopalan Balaji Professor

EDUCATION	B Tech, Civil Engineering, National Institute of Technology, Kurukshetra, India, 1989 M Tech, Quality Reliability and Operations Research, Indian Statistical Institute, Calcutta, India, 1991 Ph.D., Civil and Environmental Engineering, Utah State University, 1995
ACADEMIC EXPERIENCE	University of Colorado – Boulder, Professor, 2010-present; Associate Professor, 2007-2010; Assistant Professor, 2000-2007; Fellow of Cooperative Institute for Research in Environmental Sciences (CIRES), 2001-present Utah State University, Logan, UT, Research Assistant Professor, 1997-2003; Graduate Research Assistant, 1991-1995 Columbia University, New York, NY, Adjunct Associate Research Scientist, 200-present; Associate Research Scientist, 1997-2000; Post-Doctoral Research Scientist, 1995-1997
NON-ACADEMIC EXPERIENCE	Alembic Chemicals Ltd., Baroda, India, Intern, summer 1991 Hindustan Cables Ltd., Hyderabad, India, Intern, summer 1990 Engineers India Ltd., Cochin, India, Intern, summer 1988
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Geophysical Union American Society of Civil Engineers – Environment and Water Research Institute
HONORS AND AWARDS	Norbert Gerbier - MUMM International Award, World Meteorological Organization, 2009. Partners in Conservation Award, Department of Interior, 2009. Research Development Award, CEAE Department, University of Colorado – Boulder, 2006. College Research Award, College of Engineering and Applied Sciences, University of Colorado, Boulder, CO, 2014 Young Researcher Award, CEAE Department, University of Colorado – Boulder, 2003.
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Climate Research, Associate Editor (2008 to present) Advances in Water Resources, Associate Editor (2014 to present) Water Resources Research. Associate Editor (2009 to 2015) Geophysical Research Letters. Associate Editor (2004 to 2012) Journal of Hydrologic Engineering (ASCE). Associate Editor (2004 to 2010) State of Colorado. Member of Technical Advisory Committee, Colorado Water Availability Study (2009 to 2011) U.S. Climate Variability and Predictability Research (CLIVAR). Member of Prediction, Predictability and Applications Panel (2007 - 2012)

	American Water Works Association Research Foundation. Member of Project Advisory Committee (March 2006 – October 2009). **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Chair, July 2014 - Associate Chair Fall 2010 - 12 Curriculum Committee - Fall 2001 – Spring 2006, Fall 2009 to 2010; Executive Committee - 2012-2014 Faculty Search Committee. 2003-2004, 2006-2007, 2011-12 <u>Co-operative Institute for Research in Environmental Sciences (CIRES)</u> Executive Committee, Member. Spring 2006 – Spring 2008. Promotion Committee of Dr. Xinzhao Chu, Member. Fall 2006 to present. Graduate Student Fellowship Committee. Member, Fall 2004 – Spring 2006, Fall 2009 – Spring 2010; Chair, Fall 2005 – Spring 2006. Visiting Fellows Committee, Member. Fall 2002 – 2004, 2010-2011
PRINCIPAL PUBLICATIONS OF LAST FIVE YEARS	Samson, C., B. Rajagopalan and S. Summers, Modeling Source Water TOC Using Hydroclimate Variables and Local Polynomial Regression, *Environmental Science & Technology,* 50 (8), 4413–4421, 2016 Weirich, S., J. Silverstein and B. Rajagopalan, Resilience of Secondary Wastewater Treatment Plants: Prior Performance Is Predictive of Future Process Failure and Recovery Time, Environmental Engineering Science, 32(3), 222-231, 2015 Pavlak, G., A. Florita, G. Henze and B. Rajagopalan, Probabilistic identification of inverse building model parameters, Journal of Architectural Engineering, 20(2), 04013011, 2014 Verdin, A., B. Rajagopalan, W. Kleiber and R. Katz, Coupled Stochastic Weather Generation Using Spatial and Generalized Linear Models, Stochastic Environmental Research and Risk Assessment (SERRA), special issue, 29(2), 347-356, 2015 Bracken, C., B. Rajagopalan, M. Alexander and S. Gangopadhyay, Spatial variability of seasonal extreme precipitation in the Western United States, Journal of Geophysical Research – Atmospheres, 12(10), 4522-4533, 2015 Rajagopalan, B. and P. Molnar, Signatures of Tibetan Plateau Heating on Indian Summer Monsoon Rainfall Variability, Journal of Geophysical Research - Atmospheres, 118(3), 1170-1178, 2013
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Summer Institute 2009 for New Media Pedagogy, Scholarship, and Learning Technologies using Web 2.0 Tools, Organized by Faculty Teaching Excellence Program at the University of Colorado at Boulder, May 11-15, 2009 Chairs Workshop, University of Colorado, Boulder, August 2014-2016

Angela R. Bielefeldt Professor

EDUCATION	BS, Civil Engineering, Iowa State University, 1992 MS, Civil Engineering, University of Washington, 1994 Ph.D., Civil Engineering, University of Washington, 1996
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2012 – present; Associate Professor, 2003-2012; Assistant Professor, 1996-2003; Faculty Director Sustainable By Design Residential Academic Program, 2014-present; CEAE ABET Assessment Coordinator, 2008-present; Associate Chair CEAE 2012-13, 2014-15; Director EVEN program, 2006-2010; University of Canterbury, Christchurch, NZ (sabbatical), 2013 University of Minnesota, Braun Intertec Professor (sabbatical), 2005-06 University of Washington, Research Assistant, 1992-1996, part time Iowa State University, Research Assistant, 1987-1992, part time
NON-ACADEMIC EXPERIENCE	Remediation Technologies, Seattle, WA, Asst. Engineer, summer 1994 Montgomery Watson, Des Moines, IA, Assistant Engineer, summer 1992 Sandia National Laboratories, Albuquerque, NM, Intern, summer 1991 CH2M Hill, Reston, VA, Intern, summer 1990
PROFESSIONAL REGISTRATIONS	P.E., Colorado, 2003 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society for Engineering Education (ASEE) American Society of Civil Engineers (ASCE) Association of Environmental Engineering & Science Professors (AEESP) Water Environment Federation (WEF)
HONORS AND AWARDS	Best Paper Award from PIC IV, ASEE Annual Conference, 2016 Overall Best Paper Award from ASEE Annual Conference, 2015 Distinguished Service Award, AEESP, 2013 Outstanding Reviewer Award, ASCE Journal of Professional Issues in Engineering Education & Practice, 2012 Advisor for winning teams in the national AECOM Student Design Competition, 2012 and 2011 Advisor for the winning teams in the National WEF Student design Competition, 2012 and 2009 Outstanding Service Award, Boulder Faculty Assembly, CU, 2012
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	American Society for Engineering Education (ASEE). Environmental Division director (2010-13); Community Engagement Division chair-elect (2011-13) & secretary (2015-16), best paper committee PIC III (2013, 2015) American Society of Civil Engineers (ASCE). Corresponding member of the Civil Engineering Program Criteria Task Committee, 2013. Association of Environmental Engineering and Science Professors (AEESP). Co-organized 2013 conference. Reviews in Environmental Science and Biotechnology, publisher Springer Netherlands; Editorial Board, 2009 – present.

	International Journal for Service Learning in Engineering (IJSLE), Editorial Board 2011-present. **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Executive Committee. 2015-present. Curriculum Committee. Chair. 2011-13, 2014-2015 Assessment Coordinator. Spring 2008 to present. Environmental Engineering (EVEN) cross-disciplinary degree program Associate Director. 2014 - present. College of Engineering at the University of Colorado - Boulder Undergraduate Education Council. 2012-2013, 2014-2015. Assessment Committee. Spring 2008 to present.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Canney, N., A.R. Bielefeldt. 2016. Validity and Reliability Evidence of the Engineering Professional Responsibility Assessment Tool. *Journal of Engineering Education*. 105 (3), 452-477. Bielefeldt, A.R., N.E. Canney. 2016. Humanitarian Aspirations of Engineering Students: Differences Between Disciplines and Institutions. *Journal of Humanitarian Engineering*. 4 (1), 8-17. Bielefeldt, A.R., N. Canney. 2015. Changes in the Social Responsibility Attitudes of Engineering Students Over Time. *Science and Engineering Ethics*. DOI 10.1007/s11948-015-9706-5. Canney, N., A. Bielefeldt. 2015. Differences in Engineering Students' Views of Social Responsibility Between Disciplines. *Journal of Professional Issues in Engineering Education and Practice*. 141 (4), 04015004. http://dx.doi.org/10.1061/(ASCE)EI.1943-5541.0000248 McCormick, M., A.R. Bielefeldt, C. Swan, K. Paterson. 2015. Assessing Students' Motivation to Engage in Sustainable Engineering. *International Journal of Sustainability in Higher Education*. 16 (2), 136-154. DOI 10.1108/IJSHE-06-2013-0054 Bielefeldt, A.R. 2014. Global Interests Among First-Year Civil and Environmental Engineering Students. *Journal of Professional Issues in Engineering Education and Practice.* 140 (2), 04013016-1-9. Bielefeldt, A.R., M. W. Stewart, E. Mansfield, R.S. Summers, J.N. Ryan. 2013. Effects of chlorine and other water quality parameters on the release of silver nanoparticles from a ceramic surface. *Water Research*. 47, 4032-4039.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	ASCE Body of Knowledge 3 Workshop, Aug. 5-6, 2016. ABET Symposium. April 14-15, 2016. IEEE/ASEE Frontiers in Education Conference. Oct. 21-24, 2015. Integrating Design and Community Engagement within the Curriculum Workshop. Sponsored by EPICS, EWB-USA, and EFELTS. West Lafayette, Indiana. June 19-20, 2014. Engineering Education Research Leader Networkshops: Mentoring, Communicating, and Power Brokering for the Next Generation (NSF EEC-1314725, 1314868). Online collaborative. 2013 – 2016.

Paul S. Chinowsky Professor

EDUCATION	BArch, Architecture, Cal Poly San Luis Obispo, 1987 MArch, Architecture, Cal Poly San Luis Obispo, 1988 Ph.D., Civil Engineering, Stanford University, 1991
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2010–present; Associate Professor, 2002-2010; Associate Vice Provost 2015 – Present; Director, Mortenson Center and Mortenson Professor for Sustainable Development, 2012-2015 Georgia Institute of Technology: Associate Professor, 2000-2002; Assistant Professor, 1994-2002. Loughborough University: Visiting Professor (2005)
NON-ACADEMIC EXPERIENCE	Stone & Webster Engineering: 1991-1994, Principal Analyst
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) Academy of Management (AOM) Engineering Project Organization Society (EPOS)
HONORS AND AWARDS	Best Paper Award, Transportation Research Board Conference, 2015. Best Paper Award, Humanitarian Technology Conference, 2014. ASCE, Journal of Management in Engineering, Best Peer Reviewed Paper Award, 2012 Distinguished Service Award, Engineering Project Organization Society, 2011 Best Paper Award, EPOC Conference, 2010
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Conference Co-Chair, Engineering Project Organization Conference, Winter Park, CO, July 2014. Conference Co-Chair, Engineering Project Organization Conference, Winter Park, CO, July 2013. Conference Co-Chair, Engineering Project Organization Conference, Rheden, The Netherlands, August 2012. **Engineering Project Organization Society,** Co-Founder and Chairman 2010 - Present Contributing Author, IPCC Report 5 Editor, Journal of Engineering Project Organizations, Taylor & Francis, January 2011- Present. Member, Boulder Faculty Assembly, Executive Committee (2010 – 2012), Vice-Chair (2012-2013), Chair (2013-2015) Co-Developer and Co-Coordinator, College Undergraduate Certificate in Global Engineering (2012-2013) Member, Mortenson Center Executive Committee (2010 – 2012) Co-Coordinator, Civil Systems Graduate Program, Department of Civil, Env. And Arch. Engineering, Current

PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	• Walters, J. P., & Chinowsky, P. S. (2016). Planning rural water services in Nicaragua: A systems-based analysis of impact factors using graphical modeling. *Environmental Science & Policy*, *57*, 93-100. • Melvin, A.M., Larsen, P., Boehlert, B., Neumann, J.E., Chinowsky, P., Espinet, X., Martinich, J., Baumann, M.S., Rennels, L., Bothner, A. and Nicolsky, D.J., (2016). Climate change damages to Alaska public infrastructure and the economics of proactive adaptation. *Proceedings of the National Academy of Sciences*, p.201611056. • Espinet, X., Schweikert, A., van den Heever, N., & Chinowsky, P. (2016). Planning resilient roads for the future environment and climate change: Quantifying the vulnerability of the primary transport infrastructure system in Mexico. *Transport Policy*, *50*, 78-86. • Twerefou, D.K.; Chinowsky, P.; Adjei-Mantey, K.; Strzepek, N.L. (2015) "The Economic Impact of Climate Change on Road Infrastructure in Ghana," ***Sustainability***, ***7(9)***, 11949-11966. • Sandekian, R., Chinowsky, P., & Amadei, B. (2014). "Engineering for Developing Communities at the University of Colorado Boulder: A Ten Year Retrospective," *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, 62-77. • Chinowsky, Paul S. and Hoffman, Rod (2014). "Long-Term Viability of Mid-Size Engineering Firms," ASCE Journal of Management in Engineering, 10.1061/(ASCE)ME.1943-5479.0000328. • Neumann, James E., Price, Jason, Chinowsky, Paul, Wright, Leonard, Ludwig, Lindsay, Streeter, Richard, Jones, Russell, Smith, Joel B., Perkins, William, Jantarasami, Lesley, and Jeremy Martinich (2014). "Climate Change Risks to US Infrastructure: Impacts on coastal development, roads, bridges, and urban drainage," Climatic Change. • Chinowsky, Paul S., Price, Jason C. and Neumann, James (2013). "Assessment of Climate Change Adaptation Costs for the U.S. Road Network," Global Environment Change, 23(4): 764-773.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	First-Year Experience Annual Conference, Feb 10-14, 2017 Climate Change Impacts Symposium, EPOC 2016 Conference, August 2016. "Resiliency versus Risk: An Adaptation Challenge," Colorado Municipal League, October 2015

Sherri M. Cook **Assistant Professor**

EDUCATION	BS, Civil Engineering, Virginia Tech (VPI&SU), 2008 MS, Environmental Engineering, University of Michigan, 2009 Ph.D., Environmental Engineering, University of Michigan, 2014
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assistant Professor, 2014 – present University of Michigan, Research Assistant, 2008-2014, part time Clarkson University, Research Assistant, summer 2007 Virginia Tech, Research Assistant, 2005-2006, part time
NON-ACADEMIC EXPERIENCE	Froehling & Robertson, Sterling, VA, Intern, summer 2005
PROFESSIONAL REGISTRATIONS	E.I.T., Virginia, 2008 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	Association of Environmental Engineering & Science Professors (AEESP) Water Environment Federation (WEF) International Water Association (IWA) Society of Women Engineers (SWE)
HONORS AND AWARDS	Rackham Predoctoral Fellow, 2013-2014 Graham Sustainability Institute Doctoral Fellow, 2010-2013 National Science Foundation Graduate Research Fellow, 2009-2012 Phi Kappa Phi Honor Society National Fellow, 2008-2009 Virginia Tech College of Engineering Outstanding Senior, 2008 Morris K. Udall Scholar, 2007 and 2006
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	International Water Association Wastewater Treatment Modeling Conference. Scientific Committee (2014, 2016); Chair of Young Water Professional Scientific Committee and Workshop (2016) IWA/Water Environment Federation (WEF) Nutrient Removal and Recovery Conference. Scientific Committee (2016) Rocky Mountain Water Environment Association (RMWEA) Internship Committee (2016) Peer Review: Funding Agencies (WERF, NSF) and Journals (6) **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Curriculum Committee. 2014 to present. Graduate Committee. 2014-2015 Classroom Renovation Committee. 2015. <u>University of Colorado - Boulder</u> Udall Scholarship Selection Committee. 2016 Faculty Student Mentor Program. 2014
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF	Thompson, K.; Shimabuku, K.K.; Kearns, J.P.; Knappe, D.R.U.; Summers, R.S.; Cook, S.M. Environmental comparison between biochar and activated carbon for tertiary wastewater treatment. Accepted for publication at *Environmental Science & Technology*. Thompson, K.A.; Shimabuku, K.T.; Kearns, J.P., Knappe, D.R.U.; Summers, R.S; Cook, S.M. An environmental comparison between

LAST FIVE YEARS	powdered activated carbon and biochar for tertiary wastewater treatment. *Biochar 2016,* Corvallis, OR, August 2016. Cornejo, P.K.; Hogrewe, B.; Jones, C.H.; Cook, S.M. Improving Decision Support for Small Drinking Water Systems: An Innovative Approach to Alternatives Assessment. *American Water Works Association 16th Annual Conference & Exposition*, Chicago, IL, June 2016. Jones, C.H.; Shilling, E.; Cook, S.M. Sustainability Comparison of Innovative and Conventional Treatment Technologies for Small Systems. *Rocky Mountain Student Region AWWA and WEA 13th Annual Student Conference*, Laramie, WY, May 2016. Shilling, E.; Linden, K.; Cook, S.M. A Comparison of Life Cycle Environmental Emissions from Disinfection Technologies for Small Drinking Water Systems. *Association of Environmental Engineering and Science Professors (AEESP) Education and Research Conference*, New Haven, CT, June 2015. Cook, S.M.; Skerlos, S.J.; Love, N.G. Resource recovery from waste: A design-oriented analysis of anaerobic co-digestion stability. Oral presentation at the *Borchardt Conference*. Ann Arbor, MI, February 25, 2014. Cook, S.M.; Delgado Vela, J.; Stadler, L.G. Modeling advancing the success of engineering service projects from the classroom to the field. (failure and success analysis of water and sanitation projects in developing communities) Poster Presentation at the *AEESP Education and Research Conference*, Golden, CO, July 14-16, 2013. Cook, S.M.; VanDuinen, B.J.; Love, N.G.; Skerlos, S.J. Life cycle comparison of environmental emissions from three disposal options for unused pharmaceuticals. *Environmental Science & Technology*, *46* (10), 5535-5541, 2012.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Development Effectiveness Workshop at UIUC, Sept 29- Oct 1, 2016 CU-Boulder LEAP (Leadership Education for Advancement and Promotion) Introductory Leadership Workshop, May 12-13, 2016 AEESP-NSF Grand (Environmental Engineering) Challenges Workshop, May 19-20, 2016 CU-Boulder FTEP (Faculty Teaching Excellence Program) Learning Goals Workshop, Aug. 10, 2015. CU-Boulder FTEP Writing (Well written? Well argued!) Workshop, October 2014 (4 sessions)

Ross B. Corotis **Professor**

EDUCATION	BS, Civil Engineering, MIT, 1967 MS, Civil Engineering, MIT, 1968 Ph.D., Civil Engineering (Structural Mechanics), MIT, 1971
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 1994 – present; Dean of the College of Engineering and Applied Science, 1994-2001 The Johns Hopkins University: Professor 1981-1994; Founding Chair of the Department of Civil Engineering, 1983-1990; Associate Dean, 1990-1994 Northwestern University: Professor 1979-1981; Associate Professor, 1975-1979; Assistant Professor 1971-1974
NON-ACADEMIC EXPERIENCE	Jefferson Science Fellow, U.S. Department of State, full-time 2007-2008
PROFESSIONAL REGISTRATIONS	P.E., Colorado, 1995 – present; P.E. Maryland, 1981 – present; P.E. Illinois, 1974 – present; S.E. Illinois, 1976 – present
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) Civil Engineering Risk and Reliability Association (CERRA) International Association for Structural Safety and Reliability (IASSAR) International Forum for Engineering Decision (IFED)
HONORS AND AWARDS	National Academy of Engineering, Elected Member, 2002 University of Colorado Discovery Learning Center, Dedicated in my name, 2002 International Association for Structural Safety & Reliability, Senior Research Prize, 2005 U of Colorado Boulder Faculty Assembly Award for Teaching, 2006 Marquis Who's Who in the World, 2006 ASCE Distinguished Member, elected 2011 Charter Fellow, Engineering Mechanics Institute of ASCE, elected 2013
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	International Journal of Structural Safety Editorial Board, 1989- International Journal of Risk Assessment and Management Editorial Board, 2004- International Association for Bridge Maintenance and Safety Scientific Committee, 2002, 2004, 2006, 2010, 2012 Conferences International Association for Structural Safety and Reliability International Advisory Committee: 2012-2013 National Academy of Engineering Chair, Civil Engineering Section, 2009-2011 International Forum on Engineering Decision Making Member, Advisory Council, 2005-2010 Consortium Member, 2010- International Standards Organization U.S. Delegate to ISO 2394, 2011-

	American Society of Civil Engineers Editor, Journal of Engineering Mechanics, 2004-2010 Comm. on Disaster Resilience of Structures, Infrastructure & Communities, 2012- Risk and Resilience Measurements Committee, 2015- National Research Council (The National Academies) Committee on NIST Technical Programs, 1999-2014 (chair 2009-2014) Study Committee on Resilience of Communities behind Dams and Levees, 2011-2012 Laboratory Assessment Board, 2009- Board on Infrastructure and the Constructed Environment, 2012- Colorado Department of Economic Development and International Trade, proposal panel, 2014 Review of School of Civil & Environmental Engineering, Georgia Institute of Technology, 2016
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Hurley, M. and Corotis, R. 2014. "Perception of Risk of Natural Hazards: A Hazard Mitigation Plan Framework," International Journal of Risk Assessment and Management, 17(3), 188-211. Bonstrom, H. and Corotis, R. 2015. "Optimizing Portfolio Loss Reduction using a First-Order Reliability Method Sensitivity Analysis," Structure and Infrastructure Engineering, 11(9), 1190-1198. Bonstrom, H. and Corotis, R. 2015. "Building Portfolio Seismic Loss Assessment using the First-Order Reliability Method," Structural Safety, 52, 113-120. Bonstrom, H. and Corotis, R. 2016. "First-Order Reliability Approach to Quantify and Improve Building Portfolio Resilience," ASCE Journal of Structural Engineering, 142(8), C4014001. Lin, Y., Corotis, R. and Liel, A. 2015 "A Framework Methodology for Risk-Based Decision Making: Applications to Transportation Agencies," ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems Part A Civil Engineering, September, 1(3), 04015006-1 - 04015006-13 Corotis, R. 2015. "An Overview of Uncertainty Concepts Related to Mechanical and Civil Engineering," ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part B Mechanical Engineering, December, 1(4), 040801-1 - 040801-12. Elwood, E. and Corotis, R. 2015. "Application of Fuzzy Pattern Recognition of Seismic Damage to Concrete Structures," ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A Civil Engineering, December, 1(4), 04015011-1 - 04015011-12.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	ASCE Colorado Section, monthly meetings (4/year), 2001 – present NSF Workshop on Teaching Ethics in Foreign Extensions, 2011, 2012 Webinar on seismic base isolation, 2016 NSF Education Workshop on Teaching Structural Art, 2016 NSF Workshop on Social and Cultural Implications of Climate Change, 2016

Christopher J Corwin **Instructor**

EDUCATION	BS, Civil Engineering, University of Kentucky, 1996 MS, Civil Engineering, University of Colorado, 2007 Ph.D., Civil Engineering, University of Colorado, 2010
ACADEMIC EXPERIENCE	University of Colorado Boulder: Instructor, 2014 – present; Postdoctoral Research Associate, 2010-2011; Graduate Research Assistant, 2006-2010
NON-ACADEMIC EXPERIENCE	Jacobs Engineering, Denver, CO, Water Process Engineer, 2011-2013 Landmark Consultants, Steamboat Springs, CO, Project Manager, 2002-2006 JF Sato & Assoc., Littleton, CO, Project Manager, 2001 - 2002 Carroll & Lange, Inc, Lakewood, CO, Engineer, 1999 – 2001 Environmental Engineering Service, Lebanon, OH, Engineer, 1998-1999 STEELOX Building Systems, Mason, OH, Engineer, 1997-1998
PROFESSIONAL REGISTRATIONS	P.E., Colorado, 2002 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	Association of Environmental Engineering & Science Professors (AEESP) American Water Works Association (AWWA)
HONORS AND AWARDS	John and Mercedes Peebles Innovation in Education Award, 2016 College of Engineering Outstanding Faculty Advisor, 2016 Environmental Engineering Faculty Appreciation Award, 2016 Environmental Engineering Faculty Appreciation Award, 2015 Environmental Engineering Faculty Appreciation Award, 2014 Best Paper Award – Water Quality and Technology Division, American Water Works Association, 2013 Advisor for winning teams in the national FAA Student Design Competition, 2016 and 2014
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	**University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Faculty Advisor for Student Chapter of RMSAWWA/WEF 2014 to present <u>Environmental Engineering (EVEN) cross-disciplinary degree program</u> Curriculum Committee. 2014 to present Awards Committee. Chair 2015 to present Faculty Advisor for Student Environmental Engineers (SEVEN) 2014 to present
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF	Chowdhury, Z.K., Summers, R. S., Westerhoff, G.P., Leto, B., Nowack, K., Corwin, C. J.; Passantino, L., technical editor. (2012). "Activated Carbon: Solutions for Improving Water Quality," American Water Works Association, Denver, CO.

LAST FIVE YEARS	Seidel, C. J., and Corwin, C. J. (2013) "Total Chromium and Hexavalent Chromium Occurrence Analysis," Journal of American Water Works Association, 105(6) 37-38. Seidel, C. J., Najm, I., Blute, N.K., Corwin, C. J., and Wu, Y. (2013) "National and California Implications of Potential Hexavalent Chromium MCLs," Journal of American Water Works Association, 105(6) 39-40. Summers, R.S., Kim, S.M., Shimabuku, K., Chae, S. and Corwin, C.J. (2013) "Granular activated carbon adsorption of MIB in the presence of dissolved organic matter," Water Research, 47 (10) 3507-3513. Corwin, C. J., and Summers, R. S. (2012) "Controlling Trace Organic Contaminants with Granular Activated Carbon Adsorption," Journal of American Water Works Association, 104(1) E36-E47. Corwin, C. J. and Summers, R. S. (2011) "Adsorption and Desorption of Trace Organic Contaminants from Granular Activated Carbon Adsorbers after Intermittent Loading and Throughout Backwash Cycles," Water Research, 45 (2) 417-426.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	National Effective Teaching Institute (NETI1) Workshop, June 23-25, 2016.

John P. Crimaldi **Professor**

EDUCATION	BSE, Mechanical and Aerospace Engineering, Princeton University, 1987 MS, Civil and Environmental Engineering, Stanford University, 1992 Ph.D., Civil and Environmental Engineering, Stanford University, 1998
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2015 – present; Associate Professor, 2007-2015; Assistant Professor, 2000-2007; CEAE Associate Chair for Graduate Education, 2013-present; Affiliated Faculty, Dept. of Applied Mathematics, University of Colorado Boulder, 2010-present
NON-ACADEMIC EXPERIENCE	Northrop Aircraft Company, Engineer, 1987-1991
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society for Limnology and Oceanography American Geophysical Union
HONORS AND AWARDS	*Research Development Award, CEAE 2016* *Faculty Research Fellow,* University of Colorado, 2008-2009 *CAREER Award:* National Science Foundation, Biological Oceanography Program, 2004-2009 *Young Researcher Award:* CEAE, 2004 *Charles Hutchinson Teaching Award:* College of Engineering, University of Colorado, 2003 *Department Teaching Award:* CEAE, 2002 *Junior Faculty Development Award:* University of Colorado, 2001 *Graduate Fellowship:* Achievement Rewards for College Scientists Foundation, 1995-1996 *Graduate Fellowship:* Office of Naval Research, 1991-1994 *Donald J. Dyke Award for Excellence in Undergraduate Research:* Princeton University, 1987
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Limnology and Oceanography: Methods, Associate Editor, 2008 - present Session Organizer and Chair, "Consequences of fluid stirring and mixing: from organisms to ecosystems," American Society for Limnology and Oceanography, Ocean Sciences meeting, Honolulu, Hawaii, February 24-28, 2014. **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Associate Chair for Graduate Education, 2013-present Facilitator for selection of Department Chair, 2013 Chair of Graduate Committee, 2013-present College Outstanding Dissertation Award Committee, 2010

	Chair of Awards Committee, 2009-2013 College of Engineering at the University of Colorado - Boulder Campus Ethics Committee, CEAS Representative 2011-2014 Engineering Excellence Fund, Faculty Advisor, 2010-2014 Dean's Blue Ribbon Committee on Graduate Programs, 2012 Steering Committee, Integrated Teaching and Learning Graduate STEM Program, 2011-2012
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Pratt, K.R., Meiss, J.D. and **J.P. Crimaldi**. Reaction Enhancement of Initially Distant Scalars by Lagrangian Coherent Structures. *Physics of Fluids* **27**, no. 3, 035106, 2015. Soltys, M A, and **J.P. Crimaldi**. Joint Probabilities and Mixing of Isolated Scalars Emitted From Parallel Jets. *Journal of Fluid Mechanics* **769,** 130-153, 2015. **Crimaldi, J.P.** and T.R. Kawakami. Reaction enhancement in an unsteady obstacle wake: Implications for broadcast spawning and other mixing-limited processes in marine environments. *Journal of Marine Systems* **114**,130-137, 2015. **Crimaldi, J.P.** and R.A. Zimmer. The physics of broadcast spawning in benthic invertebrates. *Annual Review of Marine Science* **6**, 141-165, 2014. (Invited review article) **Crimaldi, J.P.** and *T.R. Kawakami. Reaction of initially distant scalars in a cylinder wake. *Physics of Fluids* **25**, 053604, 1-16, 2013. Koehl, M.A.R., **Crimaldi, J.P.**, and *D.E. Dombroski. Wind chop and ship wakes determine hydrodynamic stresses on larvae settling on different microhabitats in fouling communities. *Marine Ecology Progress Series* **479**, 47-62, 2013. Cullis, J. D. S., **Crimaldi, J. P.** and D. M. McKnight. Hydrodynamic shear removal of the nuisance stalk-forming diatom *Didymosphenia geminata*. *Limnology & Oceanography: Fluids & Environments* **3**, 256-26, 2013. **Crimaldi, J.P.** The role of structured stirring and mixing on gamete dispersal and aggregation in broadcast spawning. *The Journal of Experimental Biology* **215**, 1031-1039, 2012. (Invited review, Cover article) Soltys, M.A. and **J.P. Crimaldi**. Scalar interactions between parallel jets measured using a two-channel PLIF technique. *Experiments in Fluids* **50**, 1625-1632, 2011.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	

Shideh Dashti **Assistant Professor**

EDUCATION	BS, Civil and Environmental Engineering, Cornell University, 2004 MS, Civil Engineering, University of California at Berkeley, 2005 Ph.D., Civil Engineering, University of California at Berkeley, 2009
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assistant Professor, 2011 – present; Geotechnical Centrifuge Faculty Director 2015-present; University of California at Berkeley, Doctoral Student and Post-doctoral Associate, 2016-2010
NON-ACADEMIC EXPERIENCE	Bechtel National, Geotechnical Engineering, 2005-2016
PROFESSIONAL REGISTRATIONS	None
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE TC 104 committee member) Earthquake Engineering and Soil Dynamics Committee of ASCE Earthquake Engineering Research Institute (EERI) GeoEngineering Extreme Event Reconnaissance (GEER)
HONORS AND AWARDS	American Society of Civil Engineers (ASCE) Outstanding Reviewer Award (2016) Departmental Young Researcher Award, Civil, Architectural, and Env. Engineering, CU Boulder (2015) Dean's Faculty Fellowship, College of Engineering and Applied Sciences, CU Boulder (2015) Departmental Teaching Award, Civil, Architectural, and Env. Engineering, CU Boulder (2014) National Science Foundation (NSF) Fellow for ENHANCE (since December 2012) Outstanding Graduate Student Instructor Award from the Department of Civil and Environmental Engineering, UC Berkeley (2009) Distinguished Leadership Award, Cornell University (April 2004)
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Journal editorial board: Soils and Foundation Elected as the board member of the United States Universities Council on Geotechnical Education and Research (USUCGER), http://www.usucger.org/. Committee member of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE TC 104), ASCE Geo-Institute. Peer-reviewer for: ASCE Journal of Geotechnical and GeoEnvironmental Engineering, Geotechnique, EERI Journal of Earthquake Spectra, Canadian Geotechnical Journal, Journal of Earthquake Engineering, Geotechnical Testing Journal, Soils and Foundations, Soil Dynamics and Earthquake Engineering, Journal of Geotechnical and Geological Engineering **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE)

	Graduate Committee. 2013-present. Awards Committee. 2012 Faculty Search Committee for Environmental Engineering. 2014 Faculty Search Committee for Geotechnical Engineering. 2015, 2016
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Dashti, S., and Karimi, Z. (in press), "Ground Motion Intensity Measures to Evaluate I: the Liquefaction Hazard in the Vicinity of Shallow Founded Structures," Earthquake Spectra. Deniz, D., Arneson, E.E., Liel, A.B., Dashti, S., Javernick-Will, A. (2016). "Flood Loss Models for Residential Buildings Based on the 2013 Colorado Floods," Natural Hazards Journal, doi:10.1007/s11069-016-2615-3. Arneson, E., Deniz, D., Javernick-Will, A., Liel, A., and Dashti, S. (2016). "Information Deficits and Post-Disaster Recovery," Natural Hazards Review (accepted and in press). Hushmand, A., Dashti, S., Davis, C., McCartney, J.S. Hushmand, B. (2016). "A Centrifuge Study of the Influence of Site Response, Relative Stiffness, and Kinematic Constraints on the Seismic Performance of Buried Reservoir Structures," Soil Dynamics and Earthquake Engineering Journal, 88, 427-438. Hushmand, A., Dashti, S., Davis, C., Hushmand, B., McCartney, J., Hu, J., Lee, Y. (2016). "Seismic Performance of Underground Reservoir Structures: Insight from Centrifuge Modeling on the Influence of Backfill Soil Type and Geometry," Journal of Geotechnical and Geoenvironmental Engineering, ASCE 10.1061/(ASCE)GT.1943-5606.0001544 , 04016058. Dashti, S., Hashash, Y., Gillis, K., Musgrove, M., and Walker, M. (2016). "Development of Dynamic Centrifuge Models of Underground Structures near Tall Buildings," Soil Dynamics and Earthquake Engineering Journal, 86, 89-105. Y.H. Deng, S. Dashti, A. Hushmand, C. Davis, B. Hushmand (2016). "Seismic Response of Underground Reservoir Structures in Sand: Evaluation of Numerical Simulations using Centrifuge Experiments," Soil Dynamics and Earthquake Engineering Journal, 85, 202-216. Karimi, Z., and Dashti, S. (2016). "Seismic Performance of Structures on Liquefiable Soils: Insight from Numerical Simulations and Centrifuge Experiments," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 10.1061/(ASCE)GT.1943-5606.0001479.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Elected as the board member of the United States Universities Council on Geotechnical Education and Research (USUCGER). Committee member of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE TC 104), ASCE Geo-Institute. GeoEngineering Extreme Event Reconnaissance (GEER), including leading 1 reconnaissance team and participating in 3 others since 2011

Paul M. Goodrum Professor

EDUCATION	BS, Civil Engineering, University of Washington 1993 MS, Civil Engineering, University of Texas at Austin, 1994 Ph.D., Civil Engineering, University of Texas at Austin, 2001
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2012 – present; Nicholas R. Petry Professor in Construction Engineering and Management, 2012 – present. University of Kentucky: Professor 2011-2012; Terrill McDowell Chair of Construction Engineering and Management 2011-2012; Associate Professor 2006-2011; Assistant Professor, 2001-2006; University of Texas at Austin: Research Assistant 1998-2001; Research Assistant 1993-1994
NON-ACADEMIC EXPERIENCE	Design Civil Engineering (EIT), DDS Engineering 1996-1998; Project Engineer and Project Safety Engineering, W. L. Hailey and Company, Inc 1994-1996
PROFESSIONAL REGISTRATIONS	P.E., Kentucky (License Number 20220), 1998 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) Construction Research Council (CRC)
HONORS AND AWARDS	Blue Ribbon Committee Award AFH-10 Construction Management, National Academies Transportation Research Board, 2016 Outstanding Researcher Award, Construction Industry Institute, 2014 Distinguished Professor Award, Construction Industry Institute, 2014 Outstanding Faculty Award in Civil Engineering, University of Kentucky, 2012.
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	ASCE J. of Construction Engineering and Management – Specialty Editors of Labor and Personnel Issues – 2006 -2016 Practice Periodical of Structural Design and Construction, American Society of Civil Engineering, Editor of Special Issue dedicated to the Construction Engineering Conference in Seattle, Washington in April 2014 Construction Economics Research Network (CERN), Core Member, 2005-2012 National Academies, Transportation Research Board, Construction Management Committee Member, 2005 - Present Committee Research Coordinator, 2012 – Present Chair, 2015 - Present National Academies, Transportation Research Board, Information Technology in Construction Subcommittee, Co-Chair, 2010 - 2013

	Construction Industry Institute, Breakthrough Strategy Committee, 1999 – 2016 Construction Industry Institute, Academic Committee (elected Secretary 2005 to 2008, appointed Co-Chair 2011-2012, and appointed Chair 2012-2013), 2005-2016 Construction Industry Institute, Strategic Communications Committee, Academic Liason, 2013-2014. **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Executive Committee. 2012-2016 Graduate Committee. 2012-2013 Curriculum Committee. 2013-2014 CEAE Faculty Search Committee. 2012-2013, 2015-2016, 2016-Present (Chair)
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST YEAR	Bannier, P., Jin, H., and Goodrum, P. (2016). "Work Envelope Requirements among Piping Trades and the Influence of Global Anthromorphic Characterstics." Journal of Information Technology in Construction. Vol. 21, pg. 292-314 Karimi, H., Taylor, T., Goodrum, P., and Srinivasan, C. (2016). "The Impact of Craft Professional Staffing Difficulty on Construction Project Safety Performance." Emerald Journal of Construction Innovations. 16.3 (2016). Sweeny, J., Goodrum, P., and Miller, J. (2016). "Analysis of Empirical Data on the Effects of the Format of Engineering Deliverables on Craft Performance." Elsevier Journal of Automation in Construction in Summer. 69(2016). pp. 59-67. Goodrum, P., Miller, J., and Sweany, J. (2016). "Influence of the Format of Engineering Information and Spatial-Cognitive Ability on Craft Worker Performance." ASCE Journal of Construction Engineering and Management. DOI 04016043. Sankaran,B., O'Brien, W., Goodrum. P., Khwaja, N., and Leite, F. (2016). "Civil Integrated Management for Highway Infrastructure – Case Studies and Lessons Learned." National Academies Transportation Research Board Journal of the Transportation Research Record. 2573 (2016). pp. 10-17. Zhai, D., Shan, Y., Sturgill, R., Taylor, T., Goodrum, P. (2016). "Estimating Highway Construction Time Using Parametric Modelling." National Academies Transportation Research Board Journal of the Transportation Research Record. 2573(2016). pp. 1-9
PROFESSIONAL DEVELOPMENT ACTIVITIES	Construction Industry Institute Annual Conference, National Harbor, August 2-4, 2016.

Michael N. Gooseff Associate Professor

EDUCATION	BCE, Civil Engineering, Georgia Institute of Technology, 1996 MS, Civil Engineering, University of Colorado, 1998 Ph.D., Civil Engineering, University of Colorado, 2001
ACADEMIC EXPERIENCE	University of Colorado Boulder: Associate Professor, 2015-present; Director of the McMurdo Dry Valleys LTER program, 2015-present; Co-Director of the Graduate Hydrologic Sciences Program, 2015-present; Colorado State University, Associate Professor, 2013-2015; Penn State University, Assistant Professor, 2007-2012; Associate Professor, 2012-2013 Colorado School of Mines, Assistant Professor, 2004-2007 Utah State University, Assistant Professor, 2002-2004 Oregon State University Postdoctoral Fellow, 2002 University of Colorado, Research Assistant, 1998-2001, part time
NON-ACADEMIC EXPERIENCE	Hydrosphere Resource Consultants, geospatial technician, 1996-1998; GEDCO, process safety management technician, 1995
PROFESSIONAL REGISTRATIONS	E.I.T., Georgia, 1996 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Geophysical Union (AGU) Association for the Science of Limnology & Oceanography (ASLO) Geological Society of America (GSA) Society of Freshwater Science (SFS) Ecological Society of America (ESA)
HONORS AND AWARDS	Lead Principal Investigator of the McMurdo Dry Valleys Long-Term Ecological Research Project, 2015 – present. Outstanding Teaching Award, 2011, Penn State Engineering Alumni Society Harry West Teaching Award, 2011-2012, Department of Civil & Environmental Engineering, Penn State University Universities Council On Water Resources (UCOWR) Award for Education and Public Service to the MOCHA team, 2011 Hartz Family Development Professorship at Penn State University, 2007-2010 Outstanding Faculty Mentor, 2004, Utah State University
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	American Geophysical Union, Water Quality Technical Committee, Chair, 2014 – present; Chair elect, 2012-2014; Hydrologic Sciences Award Committee, Member, 2012-2015. Consortium of Universities for the Advancement of Hydrologic Sciences, Inc., Board of Directors, Member, 2014 – present. Environmental Protection Agency, Scientific Advisory Board on Connectivity of Waters, 2013 – 2014. Eos, Transactions of the American Geophysical Union, Editorial Board, 2009 - present Hydrology and Earth System Sciences, Associate Editor, 2009-2015

	Water Resources Research, Associate Editor, 2011-2015 WIRES Water, Associate Editor, 2012 – present. **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Curriculum Committee. 2016 - present Awards Committee. 2015 - present. <u>Center for Water, Earth Science, and Technology (CWEST)</u> Education Committee. Chair. 2016 - present.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Gooseff, MN, MA Briggs, KE Bencala, BL McGlynn, and DT Scott. 2013. Do transient storage parameters directly scale in longer, combined stream reaches? Reach length dependence of transient storage interpretations, *Journal of Hydrology*, 483: 16-25. Wohl, E, BP Bledsoe, KD Fausch, N Kramer, KR Bestgen and MN Gooseff. 2016. Management of large wood in Streams: An overview and proposed framework for hazard evaluation. *Journal of the American Water Resources Association*, 52(2): 315–335. Harvey, J, and M Gooseff, 2015. River corridor science: Hydrologic exchange and ecological consequences from bedforms to basins. *Water Resources Research*, 51(9): 6893-6922. Kelleher, C, T Wagener, B McGlynn, AS Ward, MN Gooseff and R Payn. 2013. Identifiability of transient storage model parameters along a mountain stream. *Water Resources Research*, 49(9): 5290-5306. Wollheim, WM, TK Harms, BJ Peterson, K Morkeski, CS Copkinson, RJ Stewart, MN Gooseff, and MA Briggs. 2014. Nitrate uptake dynamics of surface transient storage in stream channels and fluvial wetland. *Biogeochemistry*, 120: 239-257. Ward, AS, MN Gooseff, M Fitzgerald, TJ Voltz, and K Singha. 2014. Spatially distributed characterization of hyporheic solute transport during baseflow recession in a headwater mountain stream using electrical geophysical imaging. *Journal of Hydrology*, 517: 362-377. Ward, AS, MN Gooseff, TJ Voltz, M Fitzgerald, K Singha, and JP Zarnetske. 2013. How does rapidly changing discharge during storm events affect transient storage and channel water balance in a headwater mountain stream? *Water Resources Research*, 49(9): 5473-5486. Ward, AS, RA Payn, MN Gooseff, BL McGlynn, KE Bencala, CA Kelleher, SM Wondzell, and T Wagener. 2013. Variations in surface water-ground water interactions along a headwater mountain stream: Comparisons between transient storage and water balance analyses. *Water Resources Research*, 49(6): 3359-3374.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	National Academy of Engineering Frontiers in Engineering Education Symposium, 2011 (1 of 65 selected participants from Engineering programs across the US)

Matthew R. Hallowell **Associate Professor**

EDUCATION	BS, Civil Engineering, Bucknell University, 2004 MS, Civil Engineering, Bucknell University, 2005 Ph.D., Civil Engineering, Oregon State University, 2008
ACADEMIC EXPERIENCE	University of Colorado Boulder: Associate Professor, 2014-present; Assistant Professor, 2008-2014; Faculty Director for Civil Engineering, 2016-present, Director of the President's Teaching and Learning Collaborative, 2016-present, Associate Chair CEAE 2014-15,
NON-ACADEMIC EXPERIENCE	Expert Witness in construction injury and forensics cases Professional consultant for construction safety President, Modular Design Solutions Project Engineer, Pine Tree Engineering Project Engineer, Penn Lyon Homes Carpenter, Fenderson-Howe Builders
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society for Engineering Education (ASEE) American Society of Civil Engineers (ASCE) Construction Industry Institute (CII) The Beavers Chi Epsilon
HONORS AND AWARDS	Charles Hutchinson Memorial Teaching Award, U. of Colorado (2015) Outstanding Researcher Award, Construction Industry Institute (2015) Engineering News Record (ENR) Top 20 Under 40 (2014) Faculty Early Career Development (CAREER) Award, National Science Foundation (2013) Best Paper Award, American Society of Engineering Education Annual Conference (2013) Outstanding Advisor Award, College of Engineering and Applied Science (2013) John and Mercedes Peebles Innovation in Education Award, University of Colorado College of Engineering and Applied Science (2012) Best Paper Award, *Journal of Safety, Health, and Environmental Research* (2012) American Society of Civil Engineering New Faculty Excellence in Teaching Award (2011)
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Member of the CII Academic Committee Member of the NAE Frontiers of Engineering Education (FOEE) Member of the ASCE Safety Committee, Construction Research Council Mentor, ASCE Excellence in Civil Engineering Education (ExCEEd) **University Service** Director of the President's Teaching and Learning Collaborative, Boulder Campus, 2016-present

	Member, Future Leadership Advancement Group (FLAG) in the College of Engineering and Applied Science Member, Graduate Education Council in the College of Engineering and Applied Science Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Executive Committee. 2016-present. Graduate Committee. Chair. 2014-2015 Associate Chair for Graduate Education. 2014-2015 Study Abroad Advisor Honors Program Advisor Habitat for Humanity Campus Chapter Advisor Engineers without Borders Rwanda Advisor
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Lingard, H., **Hallowell, M.R.**, Salas, R.*, Prizadeh, P.* (2017). "Leading or lagging? Temporal analysis of safety indicators on a large infrastructure construction project. *Safety Science*, 91, 206-220. Tixier, A.J.P.*, **Hallowell, M.R.**, Rajagopalan, B., and Bowman, D. (2016). "Application of machine learning to construction injury prediction." *Automation in Construction*, Elsevier, (69) 102-114. **Hallowell, M.R.**, Hardison, D.*, and Desvignes, M.* (2016). "Information technology and safety: Integrating empirical safety risk data with building information modeling (BIM), sensing, and visualization technologies." *Construction Innovation* (16)3, 323-347. Arroyo, P., Fuenzalida, C., Albert, A.*, and **Hallowell, M.R.** (2016). "Collaborating in decision making: An experimental study comparing CBA and WRC methods." *Journal of Energy and Buildings*, 128, 132-142. Salas, R.* and **Hallowell, M.R.** (2016). "Predictive validity of safety leading indicators: An empirical assessment in the oil and gas industry." *Journal of Construction Engineering and Management*, ASCE, 04016052-1 to 04016052-11. Tixier, A.*, **Hallowell, M.R.,** Rajagopalan, B., and Bowman, D. (2016). "Automated content analysis for safety: A natural language processing system to extract precursors and outcomes from unstructured injury reports." *Automation in Construction*, 62, 45-56. **Hallowell, M.R.** and Hansen, D.* (2016). "Measuring and improving designer hazard recognition skill: Critical competency to enable prevention through design." *Safety Science*, 82, 254-263. **Hallowell, M.R.** and Yugar-Arias, I.* (2016). "Exploring fundamental causes of safety challenges faced by Hispanic construction workers in the US using Photovoice." *Safety Science*, Elsevier, 82, 199-211.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	ASCE Excellence in Civil Engineering Education (ExCEEd) workshop mentor and participant National Academy of Engineering, Frontiers of Engineering Education (FOEE) workshop President's Teaching and Learning Collaborative, University of Colorado Boulder Campus

George Hearn Associate Professor

EDUCATION	DES, Columbia Univ., 1989 MS, Columbia Univ., 1982 BE, The Cooper Union, 1979
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assoc. Prof, 1996 - present University of Colorado Boulder, Asst. Prof. 1989-1996
NON-ACADEMIC EXPERIENCE	Consulting engineer 1979-1989
PROFESSIONAL REGISTRATIONS	P.E., Colorado, New York
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	ASCE, AISC, TRB
HONORS AND AWARDS	
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Chair, TRB AHD30 Structures Maintenance Committee 2015 – 2018 Academic director, AASHTO TSP2 Western Bridge Preservation Partnership, 2012-present Member, FHWA Expert Task Group for Bridge Preservation, 2010-present Member, NAS Expert Task Group for Long Term Bridge Performance 2012-present **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Executive Committee. 2010-present. Faculty Search Committees, 2010-present
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Hearn,G., (2016). *Bridge Preservation Index and Its Relation to National Performance Management Measures*. TRB Annual Mtg., Paper 16-2301, 149. Hearn,G., (2015). *Element-Level Performance Measures for Bridge Preservation*. Trans. Res. Rec. 2481, p10-17. Hearn,G. (2014). *State Bridge Load Posting Processes and Practices*. Natl Acad., NCHRP Synthesis 453. 136p. Hearn,G. (2014). *Status of Posting for Load Among U.S. Bridges and Culverts*. TRB Annual Mtg., Paper 14-3072, 15p.

	Hearn,G, Juntunen,D., Ahmad,A.S., and Johnson,B.V. (2013). *Performance Measures for Bridge Preservation*. TRB Annual Mtg., Paper 13-1551, 15p. Hearn,G., Pan,S-Y, and Casey,W.F. (2013). *Bridge Management Practices in Idaho, Michigan and Virginia*. TRB Annual Mtg., Paper 13-0869, 14p. Hearn,G. (2012) *Deterioration and Cost Information for Bridge Management*. Colorado DOT, CDOT-2012-4, 354p. Hearn,G. (2012). *Bridge Management Practices in Idaho, Michigan and Virginia*. USDOT FHWA, http://www.fhwa.dot.gov/asset/hif12029/hif12029.pdf, 42p. Hearn,G. and Johnson,B.V. (2011). *An Overview of Identification and Tracking of Highway Bridge Maintenance Actions*. NAS-TRB, Transp. Res. Rec. No 2220, p12-20.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	FHWA training for bridge inspection using national bridge elements

Mark Hernandez Professor

EDUCATION	BS, Civil Engineering, University of California at Berkeley, 1986 MS, Civil Engineering, University of California at Berkeley, 1988 Ph.D., Civil Engineering, University of California at Berkeley, 1992 PstDoc, Applied Microbiology, University of California at Berkeley, 1995
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2009 – present; Associate Professor, 2002-2008; Assistant Professor, 1996-2002; Faculty Director Colorado Diversity Initiative, 2002-2014 University of California , Research Assistant, 1987-1992, part time
NON-ACADEMIC EXPERIENCE	Civil Engineer, *City and County of San Francisco*, Responsible to the Engineering Bureau for in-house process engineering and research projects for the City's main wastewater treatment facilities. *Oro Loma Sanitary District (OLSD)/CH2M Hill Inc.,* Oakland, CA. Served as liaison and staff engineer to CH2M Hill, Inc. for the District's master plan and expansion.
PROFESSIONAL REGISTRATIONS	P.E., Civil Engineering, California, 1996 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Association for Aerosol Research (AAAR) American Society for Microbiology (ASM) Association of Environmental Engineering & Science Professors (AEESP) Water Environment Federation (WEF)
HONORS AND AWARDS	Great Minds in STEM Foundation, Hispanic Educator of the Year, 2012 Sigma Xi, Distinguished Lectureship, 2012 President's Commendation for Advancing Diversity, University of Colorado System Award, 2008 University of Colorado at Boulder, Diversity and Equity Award, 2008 University of Colorado, Dept. of Civil Engineering, Teaching Award, 2003 Association of Environmental Engineering and Science Professors Advisor to Outstanding Doctoral Dissertation, 2001 University of Colorado, Dept. of Civil Engineering, Young Researcher Award, 2000
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Executive Committee, The Leadership Alliance, one of a five-member executive board overseeing the policy, operations and financing of this premier NGO promoting diversity in higher education. The National Academy of Science, Engineering and Medicine: committee (2016/2017): Standards for the Microbiology of the Built Environment; (2011/2012): Review of Environmental Risk Assessment for Expansion of Facilities for Experimentations with Airborne Agricultural Pathogens American Association for Aerosol Research: Editor, Journal of Aerosol Science and Technology, 2008-2013, Bioaerosol Committee Working Group Chairman, 2015-2016 University Service Director, The Colorado Diversity Initiative Principal Investigator of an AGEP grant (of 22 awarded nationwide). I conceived, designed and led

	a joint NIH-NSF funded program to recruit and integrate graduate students from socioeconomic groups that have been traditionally underrepresented in STEM PhD programs. <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Joint Program Coordinator for new Civil Engineering Program at Mesa State University, 2016 - Present <u>Environmental Engineering (EVEN) cross-disciplinary degree program</u> Graduate Admissions Committee. 2015-present.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Mehsah-Attipoe, J., Taubel, M., **Hernandez, M.**, Pitkaranta, M., Reponen, T., (2016) Toward a better understanding of the potential benefits and adversity of microbe exposures in the indoor environment, Indoor Air, *In Press*. Caicedo Ramirez, A., Ling, L., **Hernandez, M.,** (2016), Diffusion susceptibility demonstrates relative inhibition potential of sorbent-immobilized heavy metals against sulfur oxidizing acidophiles, *Journal of Microbiological Methods, 131:42-44.* **Hernandez, M.**, Perring, A.E., McCabe, K., Kok, G., Granger, G., Baumgardner, D., (2016) Chamber catalogues of optical and fluorescent signatures distinguish bioaerosol classes, *Atmospheric Measurement Techniques*, 9, 3283-3292, doi:10.5194/amt-9-3283-2016 Handorean A. M., Robertson, C., Harris, J.K, Frank, D.N, Kotter, C., Stevens M.J., Pace, N.R., **Hernandez, M.** (2105) Microbial aerosol liberation from soiled textiles isolated during routine residuals handling in modern health care setting. *Microbiome*, 3:72, DOI 10.1186/s40168-015-0132-3 Levin, H., Taubel, M., **Hernandez, M**. (2015) Microbiology of the Built Environment, Healthy Buildings Europe *Microbiome*, 3:68, 10.1186/s40168-015-0115-4 Turner, J, **Hernandez, M**, Snowder, J, Handorean, A, and McCabe, K., (2015) An optimized analytical suite for comparing toxicity effects of diesel exhaust particles and their extracts on human lung cells, *Aerosol Science and Technology* 49(**8**):599 Ling, A., Robertson, C., Harris, J.K, Frank, D.N, Kotter, C., Stevens M.J., Pace, N.R., and **Hernandez M**. (2014) High-resolution microbial community succession of microbially induced concrete corrosion in working sanitary manholes. *PLoSOne*, DOI: 10.1371/journal.pone.0116400 Ling, A., Robertson, C., Harris, J., Frank, D., Kotter, C., Stevens M., Pace, N.R., **Hernandez M**. (2014) Carbon Dioxide and Hydrogen Sulfide Associations with Regional Bacterial Diversity Patterns in Microbially Induced Concrete Corrosion, *Environmental Science & Technology,48* (13): 7357 Abu Dalo, M, Nevostrueva, S, **Hernandez, M,** (2014) Enhanced Copper (II) Removal from Acidic Water By Granular Activated Carbon Impregnated with Carboxybenzotriazole, *APCBEE Procedia*, 5: 64-6 Ling, A.L., Pace, N.R., Hernandez, M., and LaPara, T. (2013) Tetracycline Resistance and Class 1 Integron Genes Associated with Indoor and Outdoor Aerosols, *Environmental Sci & Tech* ***47*** (9): 4046
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Conference Chairman: The Microbiology of the Built Environment, University of Colorado at Boulder. 2012-2016 Indoor Air Workshop: Healthy Buildings Europe Annex 2015

Mija H. Hubler **Assistant Professor**

EDUCATION	BS, Civil Engineering, University of Illinois, 2006 MS, Civil Engineering, Cornell University, 2009 Ph.D., Civil Engineering, Northwestern University, 2013
ACADEMIC EXPERIENCE	University of Colorado Boulder, Assistant Professor, 2015 – present Massachusetts Institute of Technology, Postdoctoral Researcher, 2013-2015 Northwestern University, Research Assistant, 2009-2013, part time Cornell University, Research Assistant, 2006-2009, part time
NON-ACADEMIC EXPERIENCE	F.H. Paschen/S.N. Nielsen, Chicago, IL, Engineering Intern, summer 2005 Architectural Alliance Inc., Santa Fe, NM, Intern, summer 2004
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) International Association for Life-Cycle Civil Engineering (IALCE) Society of Engineering Sciences (SES) American Concrete Institute (ACI)
HONORS AND AWARDS	
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	RILEM Technical Committee MDC – Multi-decade creep and shrinkage of concrete: material model and structural analysis, 2012-2013 Voting Member for ACI 209 Creep and Shrinkage of Concrete, 2012 – 2013, secretary for subcommittee on rate type modeling, Member of ACI 241, Nanotechnology of Concrete Scientific Committee for International Association of Fracture Mechanics for Concrete and Concrete Structures Conference 9 Reviews in Journal of Engineering Mechanics, Materials and Structures, Construction & Building Materials, Journal of Nanomechanics and Micromechanics, Journal of Materials in Civil Engineering, and Journal of Mechanical Engineering Science, and Mechanics Research Communications, 2015 - present **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> External Joint Evaluation Committee. Coordinator. 2016
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	M. H. Hubler, and F.-J. Ulm. 2016. "Size-Effect Law for Scratch Tests of Axisymmetric Shape." *Journal of Engineering Mechanics*, 04016094. Q. Yu, J.-L. Le, M. H. Hubler, R. Wendner, G. Cusatis, and Z. P. Bazant. 2016. "Comparison of Main Models for Size Effect on Shear Strength of Reinforced and Prestressed Concrete Beams." *Structural Concrete*. RILEM TC-242-MDC, 2015. "RILEM draft recommendation: TC-242-MDC multi-decade creep and shrinkage of concrete: material model and structural analysis*," *RILEM Mater. and Str*uc., 48(4).

	R. Wendner, M. H. Hubler, and Z. Bažant, 2015. "Optimization method, choice of form and uncertainty quantification of Model B4 using laboratory and multi-decade bridge databases," *RILEM Mater. and Struc.*, 48(4). M. H. Hubler, R. Wendner, and Z. Bažant, 2015. "Statistical justification of Model B4 for drying and autogenous shrinkage of concrete and comparisons to other models," *RILEM Mater. and Struc*., 48(4). R. Wendner, M. H. Hubler, and Z. Bažant, 2015. "Statistical justification of model B4 for multi-decade concrete creep using laboratory and bridge databases and comparisons to other models," *RILEM Mater. and Struc.,* 48(4). M. H. Hubler, R. Wendner, and Z. Bažant, 2015. "Extensive Concrete Creep and Shrinkage Database – Analysis and Recommendations for Testing and Reporting," *ACI Mat. J.* Z. Bažant and M. H. Hubler, 2013. "Theory of Cyclic Creep of Concrete Based on Paris Law for Fatigue Growth of Subcritical Microcracks," *JMPS,* 63, pg. 187-200. C. Hoover, Z. Bažant, J. Vorel, R. Wendner, and M. H. Hubler, 2013. "Comprehensive Concrete Tests: Description and Results," *ACI Materials J.*, 114, pg. 92-103. Z. Bažant, M. H. Hubler, and M. Jirásek, 2013. "Improved Estimation of Long-Term Relaxation Function from Compliance Function of Aging Concrete," *ASCE J. of Eng. Mechanics*, 139(2), pg. 146-152. Z. Bažant, M. H. Hubler, and Q. Yu, "Pervasiveness of Excessive Segmental Bridge Deflections: Wake-Up Call for Creep," *ACI Structural J.* 2011, 108(6), pg. 766-774.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	NAPP Program for Teaching, Aug. 2015 PCA Education Foundation Professor's Workshop, July 2015

Amy N. Javernick-Will Associate Professor

EDUCATION	BS, Civil Engineering, University of Colorado Boulder, 1999 MS, Civil Engineering, University of Colorado Boulder, 2001 Ph.D., Civil Engineering, Stanford University, 2009
ACADEMIC EXPERIENCE	University of Colorado Boulder: Associate Professor, 2016 – present; Assistant Professor, 2010-2016-; Associate Director of Graduate Education and Research, Mortenson Center in Engineering for Developing Communities, 2015—present Stanford University: Stanford Graduate Fellow, Research Assistant, Teaching Assistant, 2006-2009
NON-ACADEMIC EXPERIENCE	Opus Northwest, L.L.C., Denver, CO, Project Manager, 2005-2006; Associate Project Manager, 2001-2004 Neenan Company, Fort Collins, CO, Project Engineer, 2000-2001 Turner Construction Company, Denver, CO, Intern, summer 1999
PROFESSIONAL REGISTRATIONS	F.E., Colorado, 1999; LEED Accreditation 2005-Present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society for Engineering Education (ASEE) American Society of Civil Engineers (ASCE) Construction Research Congress (CRC) Construction Industry Institute (CII)
HONORS AND AWARDS	Distinguished Professor Award, Construction Industry Institute, 2016 Best Paper Award, Engineering Project Organizations Conference: 2015 and 2016. Outstanding Undergraduate Research Mentor, University of Colorado-Boulder, 2015 Honorary Commended Paper, International Journal of Disaster Resilience in the Built Environment, 2014 ASCE Excellence in Civil Engineering Education (ExCEEd) New Faculty Excellence in Teaching Award ,2014 Outstanding Advisor, College of Engineering and Applied Science, University of Colorado-Boulder, 2014 Young Researcher Award, Department of CEAE, University of Colorado Boulder, 2014
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Construction Management and Economics, Editor (2016-current) Journal of Construction Engineering and Management, Assistant Specialty Editor (2011-2016) National Academy of Engineering, member of panel working on research project "Understanding the Engineering Education—Workforce Continuum" (2013-2016) Construction Industry Institute, Academic Committee (2010-2016), Conference Chair, CII-track (2014-2016), Academic Co-chair-Global Community of Practice (2012-2016) **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE)

	Associate Director, Mortenson Center in Engineering for Developing Communities (2015-present) Graduate Committee, Curriculum Committee College of Engineering at the University of Colorado - Boulder Faculty Leadership Affairs Group (FLAG), College of Engineering and Applied Science (2015-present) University Service Boulder Faculty Affairs Leadership Committee (2014-2015)
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Zerio, A., Opdyke, A., and A. Javernick-Will (2016). "Characterizing Post-Disaster Reconstruction Training Methods and Learning Styles". *Engineering Project Organization Journal.* Opdyke A., Lepropre, F., Javernick-Will, A. and M. Koschmann (2016). "Inter-organizational resource coordination in post-disaster infrastructure recovery." *Construction Management and Economics.* Antillon, E., Molenaar, K., and A. Javernick-Will (2016). "Evaluating the Effect of Contract Timing on Life Cycle Design Innovation in Public-Private Partnerships: A Comparative Case Study of Highway Projects". *Journal of Construction Engineering and Management.* Deniz, D., Arneson, E., Liel, A., Dashti, S., and A. Javernick-Will (2016). "Flood Loss Models for Residential Buildings Based on the 2013 Colorado Floods". *Natural Hazards.* Jordan, E., Javernick-Will, A. and Tierney, K. (2016). "Post-Tsunami Recovery in Tamil Nadu, India: Combined Social and Infrastructural outcomes". *Natural Hazard:* Poleacovschi, C. and A. Javernick-Will. (2016). "Spanning Knowledge Across Subgroups and Its Effects on Individual Performance". *Journal of Management in Engineering.* Litchfield, K., Javernick-Will, A., and A. Maul (2016). "Technical and Professional Skills of Engineers Involved and Not Involved in Engineering Service." *Journal of Engineering Education. 105(1): 70-92.* Litchfield, K. and A. Javernick-Will (2015). "'I am an Engineer AND': A Mixed-Methods Study of Socially Engaged Engineers". *Journal of Engineering Education*. 104(4): 393-4166. Wanberg, J., Javernick-Will, A., Taylor, J. and P. Chinowsky (2015). "The Effects of Organizational Divisions on Knowledge Sharing Networks in Multi-lateral Communities of Practice". *Engineering Project Organizations Journal* Walters, J. and A. Javernick-Will (2015). "Management of Rural Water Services in Nicaragua: A Systemic Network Approach to Evaluating Stakeholder Alignment". *International Journal of Sustainable Development and World Ecology*. 22(4): 358-367.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Penn State PACE, Innovation Research Road mapping Workshop, June 2015. NSF IDEAS Lab, Virginia, March 2014 NAE, Engineering Education to Workforce Continuum, 2013-201

Joseph Kasprzyk Assistant Professor

EDUCATION	BS, Civil Engineering, Penn State University, 2007 MS, Civil Engineering, Penn State University, 2009 Ph.D., Civil Engineering, Penn State University, 2013
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assistant Professor, 2013 – present, full time Penn State University, Research Assistant, 2006-2013, part time
NON-ACADEMIC EXPERIENCE	AECOM, Intern, 2009-2013, performed engineering analysis on project assessing climate change effects on flood insurance, part time S and G Gas and Oil, Intern, 2005-2007, performed stormwater management calculations and created land development plans, part time
PROFESSIONAL REGISTRATIONS	E.I.T., Pennsylvania, 2007
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Geophysical Union (AGU) American Society of Civil Engineers (ASCE) Association of Environmental Engineering & Science Professors (AEESP)
HONORS AND AWARDS	Early Career Research Excellence Award of the International Environmental Modelling and Software Society (iEMSs). Awarded at iEMSs meeting in Toulouse, France, July 2016. University Council on Water Resources (UCOWR) Ph.D. Dissertation Award in Natural Science and Engineering, Awarded at UCOWR Conference, June 2014. Quentin Martin Best Practice-Oriented Paper, ASCE Journal of Water Resources Planning and Management, for Fu et al. (2013) "Optimal Design of Water Distribution Systems Using Many-Objective Visual Analytics" Awarded at EWRI 2014 in Portland, OR. Reviewing awards: Environmental Modelling and Software (2014); Journal of Water Resources Planning and Management (Best Reviewer, 2014; Outstanding Reviewer; 2011); Water Resources Research (2014) Student Presentation Award, International Environmental Modelling and Software Society Meeting, July 2012 US Environmental Protection Agency Science to Achieve Results (STAR) Graduate Fellowship, 2010-2013 NSF Graduate Research Fellowship Program Honorable Mention, 2009 First Place Technical Paper/Presentation Competition, ASCE Mid-Atlantic regional student competition, 2007
INSTITUTIONAL AND PROFESSIONAL SERVICE IN	Member of AGU technical committees on hydrologic uncertainty and water and society Member of control group of Environmental Water Resource Systems (EWRS) committee of ASCE Environmental Water Resources Institute, 2016-2020 (a four year term that includes serving as Secretary, Vice Chair, Chair, and Past Chair).

LAST FIVE YEARS	Vice Chair of a task committee sponsored by EWRS within EWRI: ECSTATIC: Excellence in Systems Analysis Teaching and Innovative Communication. Guest editor of Thematic Issue on evolutionary algorithms in water resources for Environmental Modelling and Software Associate Editor, Journal of Water Resources Planning and Management, 2016-Present **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Graduate Committee. 2013-2015; 2016-2017 Curriculum Committee. 2014-2015
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Piscopo, A, R Neupauer, JR Kasprzyk. 2016. "Optimal design of active spreading systems to remediate sorbing groundwater contaminants in situ" *Contaminant Hydrology*. vol 190: 29-43. Smith, R, JR Kasprzyk, E Zagona. 2016. "Many Objective Analysis to Optimize Pumping and Releases in a Multi-Reservoir Water Supply Network" Journal of Water Resources Planning and Management. vol. 142, no. 2 Kasprzyk, JR, PM Reed, D Hadka. 2016. "Battling Arrow's Paradox to Discover Robust Water Management Alternatives" Journal of Water Resources Planning and Management. vol 142, no. 2. Matrosov, E, I Huskova, JR Kasprzyk, JJ Harou, C Lambert, PM Reed. 2015. "Many-Objective Optimization and Visual Analytics Reveal Key Trade-offs for London's Water Supply" Journal of Hydrology, vol 531, part 3: 1040-1053. Piscopo, AN, JR Kasprzyk, RM Neupauer. 2015. "An Iterative Approach to Multi-Objective Engineering Design: Optimization of Engineered Injection and Extraction for Enhanced Groundwater Remediation" Environmental Modelling and Software, vol 69: 253-261. Kasprzyk, JR, JN Ryan, "Tradeoff analysis of setback distance and density for oil and natural gas development" Presented at American Water Resources Association (AWRA) 2015 meeting, Denver, CO, Nov 2015. Maier, HM, Z Kapelan, JR Kasprzyk, JB Kollat, LS Mattot, MC Cunha, GC Dandy, MS Gibbs, E Keedwell, A Marchi, A Ostfeld, D Savic, DP Solomatine, JA Vrugt, AC Zecchin, BS Minsker, EJ Barbour, G Kuczera, F Pasha, A Castelletti, M Giuliani, PM Reed. 2014. "Evolutionary Algorithms and Other Metaheuristics in Water Resources: Current Status, Research Challenges, and Future Directions" Environmental Modelling and Software, vol. 62: 271-299.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Participated in yearly workshops with water managers at University of California Davis to improve relevance of research results, 2008-present Attended Faculty Teaching Excellence Program workshops on learning objective design and how to get the most out of the first day of class Workshop on NSF CAREER proposals at AEESP conference, 2015

Abbie B. Liel **Associate Professor**

EDUCATION	BSE, Civil and Environmental Engineering, Princeton University, 2002 MS, Civil and Environmental Engineering, University College London, 2003 MS, Building and Urban Design and Development, University College London, 2004 Ph.D., Civil and Environmental Engineering, Stanford, 2008
ACADEMIC EXPERIENCE	University of Colorado at Boulder, Assistant Professor, 2008-2015; Associate Professor 2016 – present Stanford University, Stanford, CA, Research Assistant, 2004-2008 University of Tokyo, Japan, Visiting Researcher, 2006 University College London, England, Research Assistant, 2004 Princeton University, Princeton, NJ, Research Assistant, 2002-2002
NON-ACADEMIC EXPERIENCE	Applied Technology Council, Consultant, 2005-present URS Corporation, Portland, OR, Structural Engineering Intern, 2001
PROFESSIONAL REGISTRATIONS	Professional Engineer, State of California
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE). Earthquake Engineering Research Institute (EERI). American Society of Engineering Education (ASEE) Consortium of Universities for Research in Earthquake Engineering (CUREE)
HONORS AND AWARDS	Civil Engineering Honorary Visiting Research Award, University of Auckland, 2015 Shah Family Innovation Prize, Awarded by the Earthquake Engineering Research Institute, 2015 Outstanding Faculty Advisor Award, College of Engineering, 2015 Outstanding Paper *Earthquake Spectra*, 2013 Outstanding Paper of 2012 (Runner-up) in *Journal of Performance of Constructed Facilities*, 2013 Dean's Award for Outstanding Junior Faculty Member, College of Engineering, 2013 (Awarded 2014) Faculty Teaching Award, Dept. of Civil, Environmental and Architectural Engineering, 2013 National Science Foundation CAREER Award, 2012 Selected as Next-Generation Hazards and Disaster Researcher, 2009 Research Fellowship, Japan Society for the Promotion of Science, 2006 Winner, Student Paper Competition, Earthquake Engineering Research Institute, 2006 Recipient, Graduate Research Fellowship, National Science Foundation, 2004 – 2008 Marshall Scholar, 2002 – 2004
INSTITUTIONAL AND PROFESSIONAL	Research Consultant, Applied Technology Council oject Management Committee for ATC-78, Identification and Mitigation of Non-ductile Concrete Buildings, 2010 – present

SERVICE IN LAST FIVE YEARS	rking group for ATC-63, Quantification of Building System Performance and Response Parameters, and ATC-63-1, Development of Structural Component Equivalency Methodologies, 2005 – 2010 Research Consultant, Building Seismic Safety Council, National Institute of Building Sciences Working group for Development of Simplified Seismic Design Procedures, 2010 – 2012 Co-chair, 2017 ASCE Structures Congress, Local Planning Committee EERI Annual Meeting Working Group, 2016 – present Committee on Reform of Structural Engineering Education, Structural Engineering Institute, ASCE, 2015 - present Affiliate Member, Structural Engineers Association of Colorado, 2013 – Present & Member of Sub-Committee on Snow Loads, 2012 – Present Founding Member, Young Professionals Committee, Structural Engineering Institute, American Society of Civil Engineers, 2011- 2016
PRINCIPAL PUBLICATIONS OF LAST FIVE YEARS	Liel, Abbie B., D. Jared DeBock, James R. Harris, Jeannette Torrents, Bruce Ellingwood, "Reliability-Based Design Snow Loads: II Reliability Assessment and Mapping Procedures," ASCE Journal of Structural Engineering, in Press. Deniz, Derya, Erin E. Arneson, Abbie B. Liel, Shideh Dashti and Amy N. Javernick-Will, "Flood Loss Models for Residential Buildings Based on the 2013 Colorado Floods", Natural Hazards, In Press. Harrington, Cody C. and Abbie B. Liel, "Collapse Assessment of Moment Frame Buildings, Considering Vertical Ground Shaking", Earthquake Engineering and Structural Dynamics, In Press. Welsh-Huggins, Sarah J and Abbie B. Liel, "A Life-Cycle Framework for Integrating Green Building and Hazard-Resistant Design: Examining the Seismic Impacts of Buildings with Green Roof Systems", Structure and Infrastructure Engineering, 13(1), 2017. Sattar, Siamak and Abbie B. Liel. "Seismic Performance of Non-Ductile Reinforced Concrete Frames with Masonry Infill Walls: II. Collapse Assessment", Earthquake Spectra, 32(2), pp. 819 – 842, 2016. Raghunandan, Meera, Abbie B. Liel, and Nicolas Luco. "Aftershock Collapse Vulnerability Assessment of Reinforced Concrete Frame Structures", Earthquake Engineering and Structural Dynamics, 44(3), pp. 419-439, 2015.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	TRESTLE Scholar. Transforming Education, Supporting Teaching and Learning Excellence (TRESTLE), University of Colorado Boulder Center for STEM Learning, Fall, 2016. Participant in *Creative Art of Structural and Civil Engineering Workshop*, Hosted by UMass Amherst, June, 2016.

Karl G. Linden **Professor**

EDUCATION	BS, Agricultural and Biological Engineering, Cornell University, 1989 MS, Civil/Environmental Engineering, Univ. of California Davis, 1993 Ph.D., Civil/Environmental Engineering, Univ. of California Davis, 1997
ACADEMIC EXPERIENCE	University of Colorado Boulder: Mortenson Professor in Sustainable Development, 2015 – present; Helen and Huber Croft Endowed Professor, 2011-15; Professor, 2008-2011 Duke Univ.: Associate Professor, 2005-07; Assistant Prof., 1999-2005 University of North Carolina Charlotte: Assistant Professor 1997-99 University of Colorado at Boulder Visiting Professor 2006 EAWAG, Swiss Federal Institute for Environmental Science and Technology: Visiting Professor, 2003 University of Vienna: Visiting Professor, 2003 University of California Davis, Research Assistant, 1991-1997, part time Cornel University, Research Assistant, 1987-89, part time
NON-ACADEMIC EXPERIENCE	Larry Walker and Associates, Davis CA, Project Engineer 1993 Microgen Corporation, Ithaca NY, Project Engineer 1990 Black & Veatch, Montgomery Watson Harza, US EPA, Cadmus Group, Malcolm Pirnie, Hazen, Carollo Engineers, Colorado Department of Public Health and Environment, Dow Water, Brown and Caldwell, Tetra Tech: Intermittent Engineering Consultant 1998-present
PROFESSIONAL REGISTRATIONS	BCEEM, American Academy of Environmental Engineers and Scientists, 2015-present EIT: License XE095615, California; February 1995
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) Association of Environmental Engineering & Science Professors (AEESP) American Water Works Association (AWWA) International UV Association (IUVA) International Water Association (IWA
HONORS AND AWARDS	WateReuse Person of the Year Award, 2014 Australian Water Recycling Center of Excellence Fellow 2013-2014 Pioneer Award in Disinfection and Public Health, Water Environment Federation, 2013 University Research Award, Boulder Faculty Assembly, CU 2013 Best Research Paper Award, International UV Association, 2013 Best Classic UV Paper Award, International UV Association, 2013 Faculty Research Award, College of Engineering and Applied Sci., 2012 Distinguished Faculty Award, CEAE, CU College of Engineering, 2011 Best Paper of the Year, J. AWWA 2010. *Journal AWWA*, 101(4)90+
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Board of Directors, Association of Environmental Engineering and Science Professors (AEESP) 2016 – 2019 World Health Organization (WHO) Water Quality Technical Advisory Group member 2015-present Trustee, Vice Chair (2014-2016), Water Science and Research Division, American Water Works Association 2011-17

	Associate Editor, Journal of the American Water Works Association, 2012- 2018 Associate Editor, ASCE: Journal of Environmental Engin., 2005 - 2015 **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Executive Committee. 2010-2015. Facilities Committee. Chair. 2013-2016 Mortenson Center (MCEDC) cross-disciplinary degree program Co-Director. 2015 - present. College of Engineering at the University of Colorado - Boulder Vice Chancellors Advisory Committee, 2012-2015.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Lester, Y., Thurman, E.M., Ferrer, I., Sitterley, K., Korak, J.A., Aiken, G., *Linden, K.G. (2015) "Characterization of fracturing flowback water in Colorado: Implications for water treatment" *Science of the Total Environment* 521-513: 637-644. Beck, S.E., Wright, H.B., Hargy, T.M., Larason, T.C., *Linden, K.G. (2015) "Action Spectra for Validation of Pathogen Disinfection in Medium-Pressure Ultraviolet (UV) Systems" *Water Res.*, 70:27-37 Barstow, C.K., Dotson, A.D., *Linden, K.G. (2014) "Assessing point of use ultraviolet disinfection for safe water in urban developing communities" *IWA Journal of Water and Health,* 12(4):663-669 Chatterley, C., Javernick-Will, A., Linden, K.G., Kawser, A., Laure, B., Mohini, V. (2014) "A qualitative comparative analysis of well-managed school sanitation in Bangladesh" BMC public health, Vol. 14, No. 6. Pp. 1-14. Keen, O.S. and *Linden, K.G. (2013) Degradation of Antibiotic Activity during UV/H2O2 Advanced Oxidation and Photolysis in Wastewater Effluent *Environmental Sci. & Technol* 2013 *47* (22), 13020-13030 Rodriguez, R.A., Bounty, S., *Linden, K.G. (2013) Long-Range Quantitative PCR for Determining Inactivation of Adenovirus 2 by UV Light. *J. Applied Microbiology.* 114(6) 1854-1865
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	American Water Works Association (AWWA) Water Quality Technol Conference (WQTC); Salt Lake City, UT, November 14-16, 2015 International Ultraviolet Association Research Frontiers Conference, Leeuwarden, The Netherlands. May 20, 2015. Water Sustainability in Oil and Gas Exploration: Treatment Issues, American Chemical Society, Denver CO, March 25, 2015 Association of Environmental Engineering and Science Professors Conference, Yale University New Haven CT. June 14, 2015 ReNUWIt Sunlight Symposium, Stanford University, April 2, 2013.

Ben Livneh **Assistant Professor**

EDUCATION	BS, Civil Engineering, University of Western Ontario, 2004 MS, Civil Engineering, University of Western Ontario, 2006 Ph.D., Civil Engineering, University of Washington, 2012
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assistant Professor, 2015-present; Research Scientist II, 2014-2015; Research Scientist I, 2012-2014 University of Washington, Research Assistant, 2006-2012 Seattle University, Adjunct Professor, 2008, 2010, 2011 University of Western Ontario, Research Assistant, 2004-2006
NON-ACADEMIC EXPERIENCE	Design and CAD Engineer, Lican Developments, Windsor, ON, 2006 Univercycle Recycling Co., Windsor, ON, Jiang Ying, China, 2003-2006 Quality Engineering Company, Southfield, MI, 2002 Event Manager, Canada Summer Games, London, ON, 2001
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Geophysical Union (AGU)
HONORS AND AWARDS	Symposium Scholar, DISCCRS VIII: Dissertations Initiative for the Advancement of Climate Change Research, 2013 CIRES Visiting Fellowship Award, 2012
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	American Geophysical Union (AGU) Lead session convener for both oral and poster sessions, 2013-2016 Associate Editor, Journal of the American Water Resources Association, 2016-present **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Computing Committee. 2016-present Graduate Committee. 2015-2016. Cooperative Institute for Research in Environmental Sciences (CIRES) Distinguished Lecturer Series Committee: 2015-present.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Houle, E.S., **B. Livneh**, and J.R. Kasprzyk, 2016: Exploring Snow Model Parameter Sensitivity Using Sobol' Variance Decomposition, Environmental Model and Software (accepted). Raseman, W., J.R. Kasprzyk, F. L. Rosario-Ortiz, J.R Stewart, and **B. Livneh**, 2016: Decision support systems for water treatment under climate extremes: A critical review, Environmental Science: Water Research & Technology (accepted). Yanto, **B. Livneh**, J.R. Kasprzyk, and B. Rajagopalan, 2016: Hydrologic Model Application Under Data Scarcity on Multiple Watersheds in Java Island, Indonesia, Journal of Hydrology: Regional Studies (accepted).

	Livneh B., and M.P. Hoerling, 2016: The Physics of Drought in the U.S. Central Great Plains. Journal of Climate, 29, 6783-6804. **Livneh B**., R. Kumar, and L. Samaniego, 2015: Influence of Soil Textural Properties on Hydrologic Fluxes in the Mississippi River Basin, Hydrological Processes, 29, 4638–4655. **Livneh B**., T.J. Bohn, D.S. Pierce, F. Munoz-Ariola, B. Nijssen, R. Vose, D. Cayan, and L.D. Brekke, 2015: A spatially comprehensive, hydrometeorological data set for Mexico, the U.S., and southern Canada 1950-2013, Nature Scientific Data, 2, 150042, doi:10.1038/sdata.2015.42. Buma B., and **B. Livneh**, 2015: Potential effects of forest disturbances and management on water resources in a warmer climate, Forest Science, http://dx.doi.org/10.5849/forsci.14-164. **Livneh B**., J.S. Deems, B. Buma, J.J. Barsugli, D. Schneider, N.P. Molotch, K. Wolter, and C.A. Wessman, 2015: Catchment Response to Bark Beetle Outbreak in the Upper Colorado River Basin, Journal of Hydrology 523,196–210. Pal, I., E. Towler, and **B. Livneh**, 2015: How Can We Better Understand Low River Flows as Climate Changes?, Eos Opinion, AGU, 96, doi:10.1029/2015EO033875. **Livneh, B**., J.S. Deems, D. Schneider, J.J. Barsugli, and N.P. Molotch, 2014: Filling in the gaps: Inferring spatially distributed precipitation from gauge observations over complex terrain, Water Resources Research, 50, doi:10.1002/2014WR015442. **Livneh B**., E.A. Rosenberg, C. Lin, B. Nijssen, V. Mishra, K.M. Andreadis, E.P. Maurer, and D.P. Lettenmaier, 2013: A Long-Term Hydrologically Based Dataset of Land Surface Fluxes and States for the Conterminous United States: Update and Extensions, Journal of Climate, 26, 9384–9392. **Livneh B**., and D.P. Lettenmaier, 2013: Regional parameter estimation for the Unified Land Model, Water Resources Research, doi:10.1029/2012WR012220. **Livneh, B**. and D.P. Lettenmaier, 2012: Multi-criteria parameter estimation for the unified land model, Hydrology and Earth System Sciences, 16, 3029-3048, doi:10.5194/hess-16-3029-2012.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Co-organizer, Reservoir Evaporation Workshop, Oct. 2015, CU Boulder Science-lead, Climate Change and Water Working Group, Aug. 2015 Seattle Mentor, Faculty Mentoring Students Program, CU-Boulder, 2013-2015 Resource Speaker, Water Education Foundation: Lower Colorado River Tour, 2013 Vice President, Chi Epsilon, University of Washington Chapter, 2011-2012

Diane M. McKnight Professor

EDUCATION	BS, Mechanical Engineering, Massachusetts Institute of Technology, 1975 MS, Civil Engineering, Massachusetts Institute of Technology, 1978 Ph.D., Environmental Engineering, Massachusetts Institute of Technology, 1979
ACADEMIC EXPERIENCE	University of Colorado – Boulder, Professor, 1999-present; Associate Professor, 1996-1999 Massachusetts Institute of Technology – INCRA Fellow, 1975-1979
NON-ACADEMIC EXPERIENCE	University of Colorado – Boulder; Fellow of INSTARR, 1996-present; Associate Director, Mountain Research Station, 1996-2002 U.S. Geological Survey – Research Hydrologist, National Research Program, 1979-1996; Research Advisor, Ecology, Water Resources, 1986-1992; National Research Council Fellow, 1979-1980 National Science Foundation- Arctic Sciences, Program Officer, 2015-present
PROFESSIONAL REGISTRATIONS	N/A
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Limnology and Oceanography (ASLO) American Geophysical Union (AGU) American Chemical Society (ACS) International Humic Substances Society (IHSS) Phycological Society of America (PSA) Society of Freshwater Science (SFS) Sigma Xi
HONORS AND AWARDS	Distinguished Research Lecturer, University of Colorado (2015) Faculty Research Award, College of Engineering and Applied Science, University of Colorado (2014) John Dalton Medal, European Geophysical Union (2014) American Geophysical Union, Hydrology Career Award (2014) National Academy of Engineering, member (2012) American Association for the Advancement of Science, Fellow (2009) Honorary Chair, Humic Sciences and Technology Conference XI (2008) American Geophysical Union, Langbein Lecturer (2005) American Geophysical Union Fellow (2003) USGS, Meritorious Service Award (1995) Arthur T. Ippen Award, Ralph M. Parsons Laboratory, Massachusetts Institute of Technology (1978)
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Chair, Editorial Committee, Schoolyard Children's Book Series, Long-term Ecological Research Network (2006-2015) National Academies, Chair, Committee on the Effects of Diluted Bitumen on the Environment: A Comparative Study, 2014-2016 **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Co-Director Hydrologic Sciences Graduate Program, 2004-2015 INSTARR

	Various Promotion and Tenure Committees
PRINCIPAL PUBLICATIONS OF LAST FIVE YEARS	McKnight, D. M., Cozzetto, K., Cullis, J. D. S., Gooseff, M. N., Jaros, C., Koch, J. C., Lyons, W. B., Neupauer, R., Wlostowski, A. 2015. Potential for real-time understanding of coupled hydrologic and biogeochemical processes in stream ecosystems: Future integration of telemetered data with process models for glacial meltwater streams. Water Resources Research 51(8):6725-6738. Cullis, J. D. S., L. F. Stanish, D.M. McKnight. 2014. Diel flow pulses drive particulate organic matter transport from microbial mats in a glacial meltwater stream in the McMurdo Dry Valleys. Water Resources Research, 50: 86-97, DOI: 10.1002/2013WR014061 Gabor, R. S., K. Eilers, D. M. McKnight, N. Fierer, S. P. Anderson. 2014. From the litter layer to the saprolite: Chemical changes in water-soluble soil organic matter and their correlation to microbial community composition. Soil Biology and Biochemistry, 68:166-176. Cozzetto, K. D., K. E. Bencala, M. N. Gooseff, D. M. McKnight. 2013. The influence of stream thermal regimes and preferential flow paths on hyporheic exchange in a glacial meltwater stream. Water Resources Research. 49 (9): 5552–5569. Koch, J. C., R. L. Runkel, R. Striegl, D.M. McKnight. 2013. Hydrologic controls on the transport and cycling of carbon and nitrogen in a boreal catchment underlain by continuous permafrost. Journal of Geophysical Research-Biogeosciences. 118(2): 698-712. Todd, A. S.; Manning, A. H.; Verplanck, P. L. Crouch, C., McKnight, D. M.; Dunham, R., 2012. Climate-Change-Driven Deterioration of Water Quality in a Mineralized Watershed. Environmental Science & Technology, 46: 9324-9332, DOI: 10.1021/es3020056. Cawley, K. M., Butler, K. D., Aiken, G. R., Larsen, L. G., Huntington, T. G., McKnight, D. M., 2012. Identifying fluorescent pulp mill effluent in the Gulf of Maine and its watershed. Marine Pollution Bulletin, 64:1678-1687, DOI:10.1016/j.marpolbul.2012.05.040 SanClements, M. D., Oelsner, G. P., McKnight, D. M., Stoddard, J. L., Nelson. S. J. 2012. New insights into the source of decadal increases of dissolved organic matter in acid-sensitive lakes of the Northeastern United States. Environmental Science & Technology. doi.org/10.1021/es204321x.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Serving as a Program officer in the Arctic Science program at the National Science Foundation

Keith R. Molenaar Professor

EDUCATION	BS, Architectural Engineering, University of Colorado, 1990 MS, Civil Engineering, University of Colorado, 1995 Ph.D., Civil Engineering, University of Colorado, 1996
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2011 – present; Associate Dean for Graduate Programs, 2015-present; Associate Professor, 2006-11; Assistant Professor, 1999-06; CEAE Department Chair, 2010-15; Polytechnic University of Valencia, Valencia Spain (sabbatical), 2014-15 Catholic University of Chile, Santiago, Chile (sabbatical), 2006-07 Georgia Institute of Technology: Assistant Professor, 1997-99 University of Colorado, Instructor/Research Assistant, 1994-97
NON-ACADEMIC EXPERIENCE	Pre-Construction Services Consultant, 1991-97, Architectural Resource Consultants, Inc., Boulder, Colorado; Assistant Site Superintendent, 1988-91, Spectrum Builders, Inc., Boulder, Colorado
PROFESSIONAL REGISTRATIONS	DBIA Professional, 2002-present
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers Association for the Advancement of Cost Engineering International Construction Management Association of America Design-Build Institute of America
HONORS AND AWARDS	Pan-American Academy of Engineering, 2012 Excellence in Leadership Fellow, University of Colorado, 2010 Fulbright Scholar, Fulbright Commission of Chile, 2006 Provost Faculty Achievement Award, University of Colorado, 2006 Top 50 "Trendsetter," Public Works Magazine, 2004
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	**National Service** American Society of Civil Engineers Department Heads Executive Committee, 2011-2015. International Activities Committee, ASCE Lead Representative to the Union of Pan-American Engineering Associations, 2008-2014. Design-Build Institute of America Chair, Registration Board, 2016; Member, 2009-2016. Faculty Advisor, Design-Build of America Student Competition Team, 2015 and 16. National Research Committee, 2008-2014. TRB Transportation Research Board Construction Management Committee 2014-present **University Service** College of Engineering and Applied Science Associate Dean for Graduate Programs, 2015-present Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Department Chair, 2010-14 Graduate Committee, 2015-present

PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Tran, D., Molenaar, K.R., and Gransberg, D.D. (2016). "Implementing Best-Value Procurement for Design-Bid-Build Highway Projects," *Transportation Research Record: Journal of the Transportation Research Board, National Academies*. *2573, 26-33.* Stanford, M.S. Molenaar, K.R. and Sheeran, K.M. (2016). "Application of Indefinite Delivery-Indefinite Quantity Construction Strategies at the Federal Level," *ASCE Journal of Management in Engineering,* 32(5), *04016011.* Pellicer, E., Sanz, M., Esmaeili, B. and Molenaar, K., (2016), "Exploration of Team Integration in Spanish Multi-Family Residential Construction," *ASCE Journal of Management in Engineering,* 32(5), *05016012.* Harper, C.M., Molenaar, K.R., and Cannon, J.P. (2016). "Measuring Constructs of Relational Contracting in Construction Projects," *ASCE Journal of Construction Engineering and Management,* 142(10), *04016053.* Mesa, H., Molenaar, K.R., and Alarcón, L.F. (2016). "Exploring Performance of the Integrated Project Delivery Process on Complex Building Projects," *International Journal of Project Management,* 34(7), 1089–1101. Tran, D., Molenaar, K., and Alarcón, L.F. (2016). "A Hybrid Cross-Impact Approach to Predicting Cost Variance of Project Delivery Decisions for Highways," *ASCE Journal of Infrastructure Systems,* 22(1), 04015017.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Design-Build Institute of America's Design-Build Conference and Exposition, Denver, CO, November, 2015. American Association of Port Authorities Annual Conference, San Diego, CA, October, 2015. Construction Industry Institute Annual Conference, Boston, MA, August, 2015. Transportation Research Board Annual Conference, Washington, DC, January 2015. Advanced Methodologies for Construction Management, Catholic University of Chile and Chilean Association of Construction, Santiago, Chile, September 2014. 18th International Congress on Project Management and Engineering, Alcañiz, Spain, July 2014. New York State Department of Transportation Design-Build Peer Exchange, Rochester, NY, April 2014. American Society of Civil Engineers, Department Heads Committee Meeting, Oklahoma City, OK, April 2014. Federal Highway Administration, Risk Management Peer Exchange, Atlanta, GA, March 2014. American Society of Civil Engineering, Texas Section Centennial Conference, Dallas, TX, September 2013.

Lupita D. Montoya **Assistant Professor**

EDUCATION	BS, Engineering, California State University, 1989 MS, Mechanical Engineering, Stanford University, 1991 PhD, Civil and Environmental Engineering, Stanford University, 1999
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assistant Professor, 2010 – present. Colorado School of Public Health, Environmental and Occupational Health Department, Assistant Professor, 2010-present. Rensselaer Polytechnic Institute, Assistant Professor, 2003–2009. State of New York University at Albany, Postdoctoral Fellow, 1998-2000. Harvard School of Public Health, Postdoctoral Fellow, 2000-2003
NON-ACADEMIC EXPERIENCE	The Aerospace Corporation, Asst. Engineer, El Segundo CA, summers 1988-1991 Hughes Aircraft Corporation, Asst. Engineer, Canoga Park CA, summer 1987
PROFESSIONAL REGISTRATIONS	NA
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society for Engineering Education American Society of Civil Engineers Association of Environmental Engineering & Science Professors American Association for Aerosol Research (AAAR)
HONORS AND AWARDS	Fulbright Senior Specialist (Environmental Sciences), U.S. Department of State (2011-present). David M. Darrin '40 Counseling Award, for "a faculty member who has made unusual contributions to the personal counseling of students", awarded by the *Phalanx Honor Society* at Rensselaer Polytechnic Institute (2009). Second place, 2009 International Latino Book Award, Best Biography for "Paths to Discovery: Autobiographies from Chicanas with Careers in Science, Mathematics and Engineering". First prize, (co-PI) third annual ARCHITECT magazine R+D Awards for "Active Phytoremediation Wall System", August 2009. Rensselaer NSF-RAMP UP (ADVANCE) Career Campaign Award "in recognition of outstanding scholarship and early career achievement" (March 2007).
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	American Association for Aerosol Research (AAAR): Chair of Health Effects Working Group (2015-2016); Chair of Internet Communications Committee (2015-2016); Chair of Membership Committee (2016-2017); National Secretary (2008-2011). Association of Environmental Engineering and Science Professors (AEESP). Organized "Air Quality Challenges for the Environmental Engineer of 2050" Symposium at 2013 conference.

	Member of the Senior Fulbright Specialists Program in Environmental Science, Council for the International Exchange of Scholars and the U.S. Department of State (2011-present) **University Service** Scholarship Committee, College of Engineering and Applied Science, (2011-present). Awards Committee, Department of Civil, Environmental and Architectural Engineering, (2012-present). Awards Committee, Environmental Engineering Program(2013-present). Faculty Advisor, Society of Hispanic Professional Engineers/Mexican American Engineers and Scientists, CU Chapter (2010- present).
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Barraza F., Jorquera H., Heyer J., Palma W., Edwards A.M., Muñoz M., Valdivia G., Montoya L.D (2016). "Short-term dynamics of indoor and outdoor endotoxin exposure: Case of Santiago, Chile, 2012", *Environment International*, 92-93:97-105. Ward, B.J., Yacob T.W., Montoya L.D. (2014). "Evaluation of Solid Fuel Char Briquettes from Human Waste", *Environmental Science and Technology*, 48 (16):9852–9858. Barraza F., Jorquera H., Valdivia G., Montoya L.D. (2014). "Indoor PM2.5 in Santiago, Chile, spring 2012: Source apportionment and outdoor contributions", *Atmospheric Environment,* 94:692-700. Escobedo L. E., Champion W., Li N., Montoya L. D. (2014). "Indoor Air Quality in Latino Homes in Boulder, Colorado", *Atmospheric Environment,* 92:69-75. McQuillan B., Hertzberg J. and Montoya L.D. (2014). "Flow Visualization Study of Synthetic Flow Control in the Indoor Environment", *Building and Environment,* 73:239-248. Lennox E., Kreisberg N. and Montoya L.D. (2013). "Design and Characterization of a New Area Aerosol Sampler Based on Microtrap Collection Technology", *Aerosol Science and Technology,* 47(6):626-633. Wei Z., Chen L., Thompson D. and Montoya L.D. (2014). "Effect of Size on In Vitro Cytotoxicity of Titania and Alumina Nanoparticles", *Journal of Experimental Nanoscience,* 9(6):625-638. Aydogan A. and Montoya L.D. (2011)."Formaldehyde Removal by Common Indoor Plant Species and Various Growing Media", *Atmospheric Environment* 45:2675-2682.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Sustainable Engineering Education Community Workshop, NSF, Arlington VA, August 5-6, 2014. Integrating Sustainability into Engineering: Design principles and tools to expand your educative capacity. National conference of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS, University of South Florida, October 21, 2010. Summer Leadership Institute, AAAS and SACNAS, Washington DC, July 28 – August 1, 2009.

Matthew Morris **Senior Instructor**

EDUCATION	BS, Civil Engineering, University of Colorado Boulder, 1999 MS, Civil Engineering, University of Colorado Boulder, 2002
ACADEMIC EXPERIENCE	University of Colorado Boulder: Senior Instructor, 2016 – present; Instructor, 2012-2016 United States Military Academy, West Point: Associate Professor, 2005-2006; Instructor, 2003-2005
NON-ACADEMIC EXPERIENCE	Mortenson Construction, Denver, CO, Project Manager, 2006-2012 U.S. Air Force, Civil Engineer Officer, 1999-2006
PROFESSIONAL REGISTRATIONS	P.E., Colorado, 2005 to present. LEED AP, 2007 to present
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	Design Build Institute of America (DBIA)
HONORS AND AWARDS	University of Colorado Civil Engineering Faculty Excellence Award, 2016 Dan Ivanoff Construction Engineering & Management Fellowship, 2014-present University of Colorado Architectural Engineering Faculty Excellence Award, 2014 University of Colorado Marinus Smith Award – Teaching Excellence, 2013 Meritorious Service Medal Air Force Commendation Medal National Defense Service Medal Global War on Terrorism Service Medal Korean Defense Service Medal Air Force Overseas Ribbon Air Force Longevity Service Small Arms Expert Marksmanship Company Grade Officer of the Quarter, 2003 Company Grade Officer of the Quarter, 2001
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	**University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Curriculum Committee, 2015-present Construction Engineering & Management Industry Advisory Board Executive Committee, 2012-present Associated General Contractors (AGC) Student Chapter Faculty Advisor, 2012-present College of Engineering at the University of Colorado - Boulder Scholarship Committee, 2012-present College internship committee, 2014

	College of Engineering Renovation Design/Construction Committee, 2015-2016 Larson Lab Mechanical Upgrade Construction Project liaison, 2015-2016
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Not Applicable
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Town of Superior Open Space Advisory Committee, 2014-present Design Build Institute of America Owner's Forum, 2015

Roseanna M. Neupauer **Professor**

EDUCATION	BS, Civil Engineering, Carnegie Mellon University, 1989 MS, Civil Engineering, Massachusetts Institute of Technology, 1991 MS, Mathematics, New Mexico Institute of Mining and Tech., 1999 Ph.D., Hydrology, New Mexico Institute of Mining and Tech., 2000
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2016 – present; Associate Professor, 2009-2016; Assistant Professor, 2005-2009; Faculty Director for Civil Engineering, 2014-2015; Associate Chair CEAE 2015 - present; Escuela Superior Politécnica del Litoral, Guayaquil, Ecuador, Fulbright scholar, 2015 University of Virginia, Visiting Assistant Professor, 2004-2008, Assistant Professor, 2001-2004 New Mexico Institute of Mining and Tech., Research Assistant, Teaching Assistant, Research Fellow, 1995-2000, part time Massachusetts Institute of Technology, Research Assistant, 1989-1991, part time
NON-ACADEMIC EXPERIENCE	Idaho National Engineering Laboratory, Idaho Falls, ID, Engineer, Senior Engineer, 1991-1995 F&M Associates, Allentown, PA, Intern, summers 1988, 1989 Lehigh County Authority, Wescosville, PA, Intern, summer 1987
PROFESSIONAL REGISTRATIONS	P.E., New Mexico, 1998 to present P.E., Virginia, 2002 to present
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Geophysical Union (AGU) American Society of Civil Engineers (ASCE) American Society for Engineering Education (ASEE) Geological Society of America (GSA) National Groundwater Association (NGWA) Society for Industrial and Applied Math (SIAM)
HONORS AND AWARDS	"Best Should Teach" Faculty Gold Award, Univ. of Colorado, 2016; President's Teaching Scholar, Univ. of Colorado, 2015; Fulbright U.S. Scholar Grant, 2015; Editor's Citation for Excellence in Refereeing, *Water Resources Research*, 2015, *Geophysical Research Letters*, 2013; Fellow, Geological Society of America
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Associate Editor, *Journal of Hydrology*, 2012 – present American Society of Civil Engineers – Committee on Faculty Development (Member 2009 – 2016, Secretary 2013-14, Chair 2014-15, Past Chair 2015-16); ExCEEd Teaching Workshop (Director 2010, Mentor and presenter 2011, 2012); Groundwater Council (Secretary 2012-14, Vice Chair 2014-present); Excellence in Water Resources Education Task Committee (Vice Chair 2008-14); Groundwater Management Committee (Member 2003-present); Groundwater Symposium Committee (Member 2007-present)

	American Geophysical Union – Langbein Lecture Committee (Member 2011-2014, Chair 2013-14) **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Curriculum Committee. Chair. 2015- present; Member 2013-present Coordinator for establishing a joint Civil Engineering program with Colorado Mesa University, 2015-present Representative to the Boulder Faculty Assembly (BFA), 2014-present <u>College of Engineering at the University of Colorado - Boulder</u> Undergraduate Education Council. 2010-12, 2014, 2015-present. Writing Sub-Committee. Spring 2016 – present. <u>University of Colorado</u> President's Teaching Scholar Program Selection Committee, 2015-16 GPTI Award Selection Committee, 2013-present BFA Intercollegiate Athletics Committee, 2015-present, Chair 2016-present BFA Budget and Planning Committee, 2015-present
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Okkonen, J. and R.M. Neupauer, Capture zone delineation methodology based on the maximum concentration - Preventative groundwater well protection areas for heat exchange fluid mixtures, *Water Resources Research*, 52, doi:10.1002/2016WR018715, 2016. Piscopo, A.N., R.M. Neupauer, J.R. Kasprzyk, Optimal design of active spreading systems to remediate sorbing groundwater contaminants in situ, *Journal of Contaminant Hydrology*, 190, 29-43, 2016. Wagner, D.E., R.M. Neupauer, and C. Cichowitz, Adjoint-based probabilistic source characterization in water distribution systems with transient flows and imperfect sensors, *Journal of Water Resources Planning and Management*, DOI: 10.1061/(ASCE)WR.1943-5452.0000508, 2015. Neupauer, R.M. and D.C. Mays, Engineered injection and extraction for in situ remediation of sorbing solutes in groundwater, *Journal of Environmental Engineering*, 141(6), DOI: 10.1061/(ASCE)EE.1943-7870.0000923, 2015. Lackey, G.D., R.M. Neupauer, and J. Pitlick, Effects of streambed conductance on stream depletion, *Water*, 7, 271-287, doi:10.3390/2/7010271, 2015. Neupauer, R. M., J. D. Meiss, and D. C. Mays, Chaotic advection and reaction during engineered injection and extraction in heterogeneous porous media, *Water Resour. Res*., 50, doi:10.1002/ 2013WR014057, 2014. Griebling, S.A. and R.M. Neupauer, Adjoint modeling of stream depletion in groundwater-surface water systems, *Water Resources Research*, 49, doi:10.1002/wrcr.20385, 2013.
PROFESSIONAL DEVELOPMENT ACTIVITIES	Boulder Faculty Assembly Leadership Institute, 2013-14.

Ronald Y.S. Pak Professor

EDUCATION	BE, Civil Engineering, McMaster University, 1979 MS, Civil Engineering, Caltech, 1980 Ph.D., Civil Engineering, Caltech, 1985
ACADEMIC EXPERIENCE	Professor, University of Colorado Boulder (1995-present) Associate Professor, University of Colorado Boulder (1991-95) Assistant Professor, University of Colorado Boulder (1985-91) Research Fellow, California Institute of Technology (1985)
NON-ACADEMIC EXPERIENCE	Associate Engineer, C.F. Braun & Co, California (1981-82)
PROFESSIONAL REGISTRATIONS	None
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	Engineering Mechanics Institute (EMI) American Society of Civil Engineers (ASCE) Consortium of University of Earthquake Engineering (CUREE)
HONORS AND AWARDS	Distinguished Visiting Professor, Northwest University NSF Presidential Young Investigator Award Association of Professional Engineers Gold Medal, Ontario, Canada
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	**Professional Service** Board of Directors and Executive Committee, Consortium of Universities for Earthquake Engineering (CUREE) American Society of Civil Engineers (ASCE) Engineering Mechanics Institute (Vice-Chair) American Society of Civil Engineers (ASCE) Geo-Institute Soil Dynamics Committee **University of Colorado Boulder** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Executive Committee, Personnel Committee, Faculty Search Committees Civil Engineering and Applied Math Double-Degree Program Director Junior Faculty Mentoring Committee (Chair) Facilities Committee (Chair) College of Engineering at the University of Colorado - Boulder First Level Review Committee for Promotion and Tenure
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	1. Shahmohamadi, M.; Khojasteh, A.; Rahimian, M., Pak, R.Y.S., “Rigid cylinder in a transversely isotropic half-space under lateral loads,” International J. for Numerical and Analytical Methods in Geomechanics, Volume 36, Issue 10, 2012, 1368-1386. 2. Eskandari-Ghadi, Morteza; Pak, Ronald Y. S.; Ardeshir-Behrestaghi, Azizollah, “Vertical Action of a Concentric Multi-Annular Punch on a Transversely Isotropic Elastic Half-Space,” J. Applied Mechanics, ASME, 79, Issue 4, July 2012.

	3. Soudkhah, M. and Pak, R.Y.S. "Performance of Wave-Absorbing Boundary Method for Seismic Vertical Free-Field Soil Motion in Centrifuge Simulations," Computers and Geotechnics, Volume: 43, June 2012, 155-164. 4. Pak, R.Y.S. and Soudkhah, M and Jeramy C. Ashlock, "Dynamic Behavior of a Square Foundation in Planar Motion on a Sand Stratum," Soil Dynamics and Earthquake Engineering, Vol. 42, 2012, 151-160. 5. Morteza Eskandari-Ghadi, Azizollah Ardeshir-Behrestaghi, Ronald Y.S. Pak , Mostafa Karimi and Masoud Momeni-Badeleh," Forced vertical and horizontal movements of a rectangular rigid foundation on a transversely isotropic half-space, Int. J. Analytical and Numerical methods in Geomechanics, Vol 37 , 14, 2013, 2301-2315. 6. Shahmohamadi, M.; Khojasteh, A.; Rahimian, M.; et al., " Dynamics of a Cylindrical Pile in a Transversely Isotropic Half-Space under Axial Excitations, J. Engrg. Mech., ASCE, Vol. 139, Issue 5, 568-579, 2013. 7. Naeeni, MR , Eskandari-Ghadi, M.)[, Ardalan, Alireza A and Pak, R. Y. S. "Asymmetric motion of a transversely isotropic thermoelastic half-space under time-harmonic buried source," ZAMP Zeitschrift für Angewandte Mathematik und Physik, Vol.65, 5, 2014, 1031-51. 8. Zhang ZC, Liu HL and Pak RYS "Computational Modeling of Buried Blast-induced Ground Subsidence and Ground Motion," Geomechanics and Engineering, Vol. 7, No. 6, Dec 2014, 613-631. 9. M. R. Naeeni, M. Eskandari-Ghadi, A. A. Ardalan, R. Y. S. Pak, M. Rahimian, Y. Hayati, "Coupled thermoviscoelastodynamic Green's functions for biomaterial half-space, Journal of Applied Mathematics and Mechanics/ Zeitschrift für Angewandte Mathematik und Mechanik (ZAMM), Vol. 95 Issue: 3, 260-282, 2015. 10. Kalantari, M, Khojasteh, A., Mohammadnezhad, H., Rahimian, M., Pak, R. Y. S., "An inextensible membrane at the interface of a transversely isotropic bi-material full-space," Int. J. Engrg. Science, Vol. 91, 34-48, 2015 (DOI: 10.1016/j.ijengsci.2015.02.004) 11. Farzanian M., Arbabi F. and Pak R. "PML Solution of Longitudinal Wave Propagation in Heterogeneous Media." Journal of Earthquake Engineering and Engineering Vibration, 2016,15 (2), 357-368. 13. Hansen, C. and Pak, R.Y.S. "Centrifuge Characterization of Buried, Explosive-Induced Soil Ejecta Kinematics and Crater Morphology," J. Dynamic Behavior of Materials, 2(3), 2016, 306–325
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Invited lecture, Hohai University, China Invited lecture, Northwest University, China Civil Engineering and Applied Mathematics Dual Degree Program development Civil Engineering–Engineering Science Program Development

W. Tad Pfeffer **Professor**

EDUCATION	BS, Geology, University of Vermont, 1976 MS, Geology, University of Maine, 1981 Ph.D., Geophysics, University of Washington, 1987
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, CEAE, 2006 – present; Associate Professor, CEAE, 1999-2006; Fellow, Institute of Arctic and Alpine Research (INSTAAR), 1997-present; Assistant Research Professor, Geological Sciences, 1995-1999; Research Associate, INSTAAR, 1988-1997; Post-Doctoral Researcher, INSTAAR, 1987-1988.
NON-ACADEMIC EXPERIENCE	President, W.T. Pfeffer Geophysical Consultants LLC, Nederland Colorado, USA.
PROFESSIONAL REGISTRATIONS	N/A
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Geophysical Union International Glaciological Society
HONORS AND AWARDS	Jefferson Science Fellow (National Academy of Sciences), 2015-2016 Nye Lecture, American Geophysical Union, December 2011. University of Colorado Council on Research and Creative Work, Sabbatical year support for 2007-2008. Graham Foundation for Advanced Studies in the Fine Arts, Chicago, Illinois. Grant support for research and photography for *The Hand of the Small Town Builder* (published by David R. Godine, 2014), 2003
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Editor in Chief, Oxford University Press Oxford Research Review/Natural Hazard Science, 2013-Present Lead Author, IPCC AR5 WGI, Chapter 13 (Sea Level Change); 2010 – 2013. Invited participant, Climate Change Impacts and Integrated Assessment Workshop/Snowmass Energy Modeling Forum, Snowmass, Colorado, August 2013. Committee Member, National Academy of Sciences, National Committee for the International Union of Geodesy and Geophysics, 2012 – 2015. Sigma Xi Distinguished Lecturer (2011-2012) University Service Academic Affairs Committee, Boulder Faculty assembly (2007-2012) Secretary, Boulder Faculty Assembly (2006 – 2007) Search Committee member, CU Graduate School Dean/Vice Chancellor for Research (2007) CEAE Committee Work: Facilities Committee (2000-2006)

	CEAE Curriculum Committee (2011)
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Bahr, D. B., W. T. Pfeffer, and G. Kaser (2015), A Review of Volume-Area Scaling of Glaciers, Reviews of Geophysics, 52, doi:10.1002/2014RG000470. Bahr, D.B., W.T. Pfeffer, and G. Kaser. (2014) Glacier volume estimation as an ill-posed inversion. Journal of Glaciology, 60(223), 2014 doi: 10.3189/2014JoG14J062 Pfeffer, W.T., A.A. Arendt; A. Bliss; T. Bolch; J.G. Cogley; A.S. Gardner; J-O Hagen; R. Hock; G. Kaser; C. Kleinholz; E.S.Miles; G. Moholdt; N.Mölg; F.Paul; V. Radić; P. Rastner; B.H. Raup; J. Rich; M.J. Sharp; and the Randolph Consortium. (2014) The Randolph Glacier Inventory: A globally complete inventory of glaciers. Journal of Glaciology. Gregory, J.M., J.A. Church, P.U. Clark, A.J. Payne, M.A. Merrifield, R.S. Nerem, P.D. Nunn, W.T. Pfeffer, D. Stammer, (2014). Comment on "Expert assessment of sea-level rise by AD 2100 and AD 2300", by Horton et al. (2014), Quat. Sci. Rev., 97 pp. 193-194, 10.1016/j.quascirev.2014.05.24 Gardner, A. S., G. Moholdt, J. G. Cogley, B. Wouters, A. A. Arendt, J. Wahr, E. Berthier, R. Hock, W. T. Pfeffer, G. Kaser, S. R. M. Ligtenberg, T. Bolch, M. J. Sharp, J. O. Hagen, M. R. van den Broeke & F. Paul, A Reconciled Estimate of Glacier Contributions to Sea Level Rise: 2003 to 2009. Science, 340, 852-857, 2013 Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W. T. Pfeffer, D. Stammer, A.S. Unnikrishnan, (2013). Sea Level Rise by 2100. Science, 342(6165), p. 1445-1445. National Research Council, Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future, The National Academies Press, Washington, D.C., 2012 Pfeffer, W.T., Adaptation to a Non-steady Coastal Environment: Designing Infrastructure in a Non-Steady World, The International Journal of the Constructed Environment, V 2, No. 3, pp. 81-92, 2012 Pfeffer, W.T., Land Ice and Sea Level Rise: A Thirty-Year Perspective, Oceanography 24(2): 94–111, http://dx.doi.org/10.5670/oceanog.2011.30, 2011
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	None

Fatemeh Pourahmadian **Assistant Professor**

EDUCATION	BSc, Mechanical Engineering, University of Tabriz, Iran, 2007 MSc, Mechanical Engineering, Iran University of Science and Technology, Iran, 2010 MSc, Geo Engineering, University of Minnesota, Iran, 2015 PhD, Civil Engineering, University of Minnesota, 2016
ACADEMIC EXPERIENCE	University of Minnesota, Twin Cities, MN, Postdoctoral Fellow in Waves & Imaging Laboratory, 2016; Graduate Research Assistant, 2011-2016 Iran University of Science and Technology, Tehran, Iran, Research Associate in Experimental Modal Analysis Laboratory, 2010-2011; Graduate Research Assistant, 2008-2010
NON-ACADEMIC EXPERIENCE	HEPCO, Arak, Iran, Intern, summer 2004 Wagon Pars CO, Arak, Iran, Intern, summer 2007
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	Society of Engineering Science (SES) Engineering Mechanics Institute (EMI) American Society of Mechanical Engineers (ASME) American Rock Mechanics Association (ARMA)
HONORS AND AWARDS	Sommerfeld Fellowship, University of Minnesota, 2011-2012 Daneshy Fellowship, University of Minnesota, 2014-2015 Exceptional student award, Iran University of Science and Technology, 2009
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Reviewer for Journal of Mechanical Systems and Signal Processing International Journal of Rock Mechanics and Mining Sciences Journal of Inverse Problems in Science and Engineering
PRINCIPAL PUBLICATIONS OF LAST FIVE YEARS	Pourahmadian, F., B.B. Guzina and H. Haddar, Generalized linear sampling method for elastic-wave sensing of heterogeneous fractures, *Inverse Problems,* In press, 2016 Pourahmadian, F., B.B. Guzina, On the elastic-wave imaging and characterization of fractures with specific stiffness, *International Journal of Solids and Structures,* In press, 71, 126-140, 2015 Guzina B.B., F. Pourahmadian, Why the high-frequency inverse scattering by topological sensitivity may work. *Proceedings of the Royal Society A* 471, 20150187, 2015 Pourahmadian F., S. G. Mogilevskaya, Complex variables-based approach for analytical evaluation of boundary integral representations of three-dimensional acoustic scattering. *Engineering Analysis with Boundary Elements* 53, 9-17, 2015 Pourahmadian F, Ahmadian H, Jalali H. Modeling and identification of

	frictional forces at a contact interface experiencing vibro- impacts. *Journal of Sound and Vibration* 331, 2874-2886, 2012 Jalali H, H Ahmadian, F Pourahmadian, Identification of micro- vibro-impacts at the boundary condition of a nonlinear beam, *Journal of Mechanical Systems and Signal Processing* 25, 1073-1085, 2011 Pourahmadian F, B. B. Guzina, Elastic anatomy of fracture in rock, *Geophysical Research Letters*, under review, 2016
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	

Harihar Rajaram, Professor

EDUCATION	B. Tech, Indian Institute of Technology, Madras, 1985 MS, Civil Engineering, University of Iowa, 1987 Sc.D., Civil Engineering, Massachusetts Institute of Technology, 1991
ACADEMIC EXPERIENCE	University of Colorado Boulder: President's Teaching Scholar, 2012-present; Professor, 2004 – present; Associate Professor, 2000-2004; Assistant Professor, 1993-2000; Affiliate Faculty Member, Applied Mathematics, 1996-present
NON-ACADEMIC EXPERIENCE	None
PROFESSIONAL REGISTRATIONS	None
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Geophysical Union Society for Industrial and Applied Mathematics
HONORS AND AWARDS	President's Teaching Scholar, University of Colorado, 2012 Clarence Eckel Prize for Faculty Excellence, 2016 College of Engineering Faculty Research award, 2016 Editor, Water Resources Research, 2013-present
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Editor, Water Resources Research, 2013-present ICESat2 Science Definition Team Review Panel, NASA, 2014. **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Executive Committee. 2014-present. <u>College of Engineering at the University of Colorado - Boulder</u> First-Level Review Committee, 2012-2014. Faculty Research Committee, 2013-15. <u>University of Colorado</u> Research Review Board, 2014-present Faculty Teaching Excellence Program Associate, 2014-present
PRINCIPAL PUBLICATIONS OF THE LAST FIVE YEARS	·Pandey, S. and H. Rajaram, Modeling the influence of preferential flow on the spatial variability and time-dependence of mineral weathering rates, *Water Resources Research*, 52, doi: 10.1002/2016WR019026, 2016 ·Colgan, W., H. Rajaram, W. Abdalati, C. McCutchan, R. Mottram, M. S. Moussavi, and S. Grigsby, Glacier crevasses: Observations, models, and mass balance implications, , *Rev. Geophys.*, 54, 119–161, 2016. doi:10.1002/2015RG000504 ·Birdsell, D. T., H. Rajaram, D. Dempsey, and H. S. Viswanathan, Hydraulic fracturing fluid migration in the subsurface: A review and

	expanded modeling results, Water Resour. Res., 51, 2015. doi:10.1002/ 2015WR017810 ·Pandey, S.N., A. Chaudhuri, H. Rajaram, S. Kelkar, Fracture transmissivity evolution due to silica dissolution/precipitation during geothermal heat extraction, *Geothermics* 57, 111–126, 2015. doi: 10.1016/j.geothermics.2015.06.011 ·Phillips, T; Rajaram, H; Colgan, W; Steffen, K; Abdalati, W: Evaluation of cryo-hydrologic warming as an explanation for increased ice velocities in the wet snow zone, Sermeq Avannarleq, West Greenland; *Journal Of Geophysical Research-Earth Surface* 118(3), 1241-1256 DOI: 10.1002/jgrf.20079, 2013
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	None

Richard A. Regueiro Associate Professor

EDUCATION	BSE, Civil Engineering Systems, University of Pennsylvania, 1991 SM, Aeronautics & Astronautics, Massachusetts Institute of Technology, 1993 Ph.D., Civil & Environmental Engineering, Stanford University, 1998
ACADEMIC EXPERIENCE	University of Colorado Boulder: Associate Professor, 2012-present; Assistant Professor, 2005-2012 Oxford University, United Kingdom (sabbatical), Fall 2014 Stanford University (sabbatical), Winter-Spring 2014
NON-ACADEMIC EXPERIENCE	Sandia National Laboratories, Livermore, CA, Principal Member of Technical Staff (2004-2005), Senior Member of Technical Staff (1998-2004)
PROFESSIONAL REGISTRATIONS	none
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	Engineering Mechanics Institute (EMI), American Society of Civil Engineers (ASCE)
HONORS AND AWARDS	Research Development Award (2012). Department of Civil, Environmental, and Architectural Engineering, University of Colorado Boulder.
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	**Associate Editor/ Editorial Board Member:** ASCE Journal of Engineering Mechanics (01/12-present), Acta Geotechnica (10/12-present), International Journal for Numerical and Analytical Methods in Geomechanics (09/13-present) **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Computer Committee Member, Chair (08/15-present) Curriculum Committee Member (8/15-present) <u>University of Colorado Boulder</u> Boulder Campus Cyberinfrastructure Board (BCCB) (1/15-present).
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Regueiro, R.A., Duan, Z., Wang, W., Sweetser, J.D., Jensen, E.W. (2016) General formulation of a poromechanical cohesive surface element with elastoplasticity for modeling interfaces in fluid-saturated geomaterials, Int. J. Multi. Comp. Eng., accepted. Regueiro, R.A., Duan, Z., Yan, B. (2016) Overlapped-coupling between spherical discrete elements and micropolar finite elements in one dimension using a bridging-scale decomposition for statics, Eng. Comput. 33(1):28-63. Bennett, K., Regueiro, R.A., Borja, R.I. (2016) Finite strain elastoplasticity considering the Eshelby stress for materials undergoing plastic volume change, Int. J. Plast. 77:214-245. Zhang, B., Regueiro, R.A. (2015) On large deformation granular strain measures for generating stress-strain relations based upon three-

	dimensional discrete element simulations, Int. J. Solids Struct 66:151-170. Burd, H.J., Regueiro, R.A. (2015) Finite element implementation of a multiscale model of the human lens capsule, Biomech. Model. Mechanobiology 14(6):1363-1378. Wang, W., Regueiro, R.A., McCartney, J.S. (2015) Coupled axisymmetric thermo-poro-mechanical finite element analysis of energy foundation centrifuge experiments in partially saturated silt, Geotechnical and Geological Engineering 33(2):373-388.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Multi-scale mechanics of particulate media, with K. Kamrin, J. Andrade, D. Hennan (lead), SES2016, University of Maryland, College Park, October 2016. Computational Geomechanics, with J. Andrade, R. Borja, Q. Chen, M. Manzari, S. Sun (lead), J. White, EMI2016, Vanderbilt University, May 2016. Multi-scale mechanics of particulate media, with K. Kamrin, J. Andrade, D. Hennan (lead), SES2015, Texas A&M University, October 2015. Computational Geomechanics (as lead organizer), with J. Andrade, R. Borja, M. Manzari, J. White, EMI2015, Stanford University, June 2015.

Zhiyong (Jason) Ren Associate Professor

EDUCATION	BS, Environmental Engineering, Tianjin Ins. Urban Construction, 2000 MS, Environmental Engineering, Tianjin University, 2003 Ph.D., Environmental Engineering, Penn State University, 2008
ACADEMIC EXPERIENCE	University of Colorado Boulder: Associate Professor, 2013 - present; University of Colorado Denver: Assistant Professor, 2008-2013; Director, Center for Sustainable Urban Infrastructure, 2012-2013; National Renewable Energy Lab, Visiting Professor, 2009-10; 2015-present Penn State University, Research Assistant, 2004-2008, part time
NON-ACADEMIC EXPERIENCE	Bioelectric, Inc, Denver, CO, CTO, 2013-2015, part time North China Municipal Eng. Design and Research Institute/Spring Environmental, LLC, Environmental Engineer, 2013-2014
PROFESSIONAL REGISTRATIONS	E.I.T., Ohio, 2006 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	Association of Environmental Engineering & Science Professors (AEESP) American Chemical Society (ACS) Water Environment Federation (WEF)
HONORS AND AWARDS	2015 Research Development Award, CEAE, CU Boulder 2015 New Inventor of the Year Award, CU Technology Transfer Office 2013 (Faculty Advisor) Graduate School Outstanding Ph.D Dissertation Award (Wang) 2012 Excellence in Review Award, Environmental Science & Technology (ES&T) 2012 University Award for Excellence in Research and Creative Work, CU Denver 2012 Outstanding Faculty in Research Award, CEAS, CU Denver 2012 Chang Junior Faculty Achievement Award, CEAS CU Denver
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Association of Environmental Engineering and Science Professors (AEESP) Education Committee – Co-chair Chinese-American Professors in Environmental Engineering and Science (CAPEES) President, Chairman Denver Metro Wastewater Reclamation District CPG Committee Peer Reviewer and Panelist for NSF, DOE, EPA, USDA, and many academic journals Reviews in Environmental Science and Biotechnology, publisher Springer Netherlands; Editorial Board, 2009 – present. International Journal for Service Learning in Engineering (IJSLE), Editorial Board 2011-present. **University Service** Boulder Faculty Assembly, Diversity Committee, 2015- Member, Task Force for Bioengineering Department and Degrees, College of Engineering, 2014

	Member, Graduate Committee, Civil, Environmental and Architectural Engineering, 2013-present
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	1. Lu, L., Hou, D., Wang, X., Jassby, D., Ren, ZJ. Active H2 Harvesting Prevents Methanogenesis in Microbial Electrolysis Cells, *Environmental Science & Technology Letters*, 2016, 3 (8), 286-290. 2. Wang, X., Zhou, L., Lu, L., Lobo, F., Li, N., Wang, H., Park, J., Ren, ZJ. Alternating Current Influences Anaerobic Electroactive Biofilm Activity. *Environmental Science & Technology*, 2016, 50 (17), 9169-9176 3. Mao, D., Lu, L., Revil, A., Zuo, Y., Hinton, J., Ren, ZJ. Geophysical Monitoring of Hydrocarbon-Contaminated Soils Remediated with a Bioelectrochemical System, *Environmental Science & Technology*, 2016, 50 (15), 8205-8213 4. Hou, D., Lu, L., Ren, ZJ. Microbial Fuel Cells and Osmotic Membrane Bioreactors Have Mutual Benefits for Wastewater Treatment and Energy Production, *Water Research*, 2016, 98, 183-189. 5. Ren, ZJ*., Umble, AK. Water Treatment: Recover Wastewater Resources Locally. *NATURE*, 2016, 529, 25. 6. Huggins, TM., Haeger, A., Biffinger, JC*., Ren, ZJ*. Granular biochar compared with activated carbon for wastewater treatment and resource recovery *Water Research*, 2016, 94, 225-232. 7. Lu, L., Huang, Z., Rau, G., Ren, ZJ* Microbial Electrolytic Carbon Capture for Carbon Negative and Energy Positive Wastewater Treatment. *Environmental Science & Technology*, 2015, 49, 8193-8201. 8. Lu, L., Zeng C., Wang, L., Yin, X., Jin S., Lu, A., Ren, ZJ Graphene Oxide and H2 Production from Bioelectrochemical Graphite Oxidation. *Scientific Reports*, 2015, 5, 16242. 9. Wang, H., Park, J., Ren, ZJ*, Practical Energy Harvesting from Microbial Fuel Cells: A review. *Environmental Science & Technology*, 2015, 49, 3267-3277. 10. Wang, H., and Ren, ZJ*. Bioelectrochemical metal recovery from wastewater: A review. *Water Research*, 2014, 66, 219-232.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Grand Challenges in Environmental Engineering Workshop, April, 2016 AEESP Workshop on Environmental Engineering Education, July, 2015

Fernando Rosario-Ortiz **Associate Professor**

EDUCATION	BS, Chemistry, University of Puerto Rico, 1999 MS, Chemistry, California Institute of Technology, 2002 D. Env., Environmental Science and Engineering, University of California, Los Angeles, 2006
ACADEMIC EXPERIENCE	University of Colorado Boulder: Associate Professor, 2015 – present; Assistant Professor, 2008-2015 Visiting Professor, Institute of Biochemistry and Pollutant Dynamics, Environmental Chemistry Group, ETH, Zurich, 2015-2016 Visiting Scientist, Swiss Federal Institute of Aquatic Sciences and Technology, EAWAG, Dübendorf, Switzerland, 2015-2016 Post Doctoral, Southern Nevada Water Authority, Henderson, Nevada, 2006-2008
NON-ACADEMIC EXPERIENCE	Instructor, Environmental Charter High School, Lawndale, California, 2003
PROFESSIONAL REGISTRATIONS	N/A
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Chemical Society (1995-present) American Water Works Association (2003-present) International Ozone Association (2007-present) International Water Association (2008-present) Association of Environmental Engineering and Science Professors (2008-present) International Humics Substances Society (2005-present)
HONORS AND AWARDS	University of Colorado, Boulder, Provost Faculty Achievement Award, 2016 Shaye Faculty Fellowship, University of Colorado, Boulder 2016-2019 Best paper award, Journal of the American Water Works Association, 2016 College of Engineering and Applied Science Dean's Award for Outstanding Junior Faculty, University of Colorado Boulder, 2015 University of Colorado Boulder Faculty Assembly Faculty Recognition Award, 2015 National Science Foundation CAREER award, 2015 College of Engineering and Applied Science Dean's Award for Professional Development, University of Colorado Boulder, 2014 Excellence in Review Award, Environmental Science and Technology, 2014 Faculty research development award, Department of Civil, Environmental and Architectural Engineering, University of Colorado Boulder, 2014 American Water Works Association, Water Science & Research Division Volunteer Recognition Award, 2014 Outstanding Faculty Award, Student Leadership Council, College of Engineering and Applied Science, University of Colorado Boulder, 2013

	ASCE Fellowship to attend the ExCEEd workshop, Florida Gulf Coast University, July 21-26th, 2013
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Member of the Bounder Faculty Assembly Faculty Affairs Committee, 2015 Chair of interview committee for CEAE, 2014 First year mentoring student program, including being a member of the ad-hoc executive committee for the program, Boulder Faculty Assembly, Fall 2013-2015 Environmental Engineering Program Steering Committee (2011-2012) Reviewer for numerous journals, including Environmental Science and Technology, Water Research, Chemosphere, Journal of the American Water Works Association. Organizer for numerous scientific symposia for the American Chemical Society and the Association of Environmental Engineering and Science Professors
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	McKay, G.; Couch, K.; Mezyk, S. P.; Rosario-Ortiz, F. L. Investigation of the coupled effects of molecular weight and charge transfer interactions on the optical and photochemical properties of dissolved organic matter. Environmental Science and Technology, 2016, 50, 15, 8093-8102 Rosario-Ortiz, F. L.; Rose, J. B.; Speight, V. L.; von Gunten, U.; Schnoor, J. How do you like your tap water? Science, 2016, 351, 6276, 912-914 Arias, M.; Cawley, K.; Rosario-Ortiz, F. L. Enhanced DOC removal using anion and cation ion exchange resins. Water Research, 2016, 88, 1, 981-989 Korak, J. A.; Rosario-Ortiz, F. L.; Summers, R. S. Evaluation of optical surrogates for the characterization of DOM removal by coagulation. Environmental Science: Water Research and Technology, 2015, 1, 493-506 McKay, G.; Rosario-Ortiz, F. L. Temperature dependence of the photochemical formation of hydroxyl radical from dissolved organic matter. Environmental Science and Technology, 2015, 49, 7, 4147-4154 Cawley, K.; Korak, J. A.; Rosario-Ortiz, F. L. Quantum yields for the formation of reactive intermediates from dissolved organic matter samples from the Suwanee River. Environmental Engineering Science, 2015, 32, 1, 31-37
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	ASCE EXCEED Workshop, 2013

Joseph N. Ryan Professor

EDUCATION	B.S., Geological Engineering, Princeton University, 1983 M.S., Civil and Environmental Engineering, Massachusetts Institute of Technology, 1988 Ph.D., Civil and Environmental Engineering, Massachusetts Institute of Technology, 1992
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2004-present; Associate Professor, 2000-2004; Assistant Professor, 1993-2000; Director, EVEN Program, 2001 to 2006 and 2012 to 2013 University of Canterbury, Christchurch, NZ (sabbatical), 2008 Yale University, New Haven, CT (sabbatical), 2001 U.S. Geological Survey, postdoctoral research associate, 1992-1993 Massachusetts Institute of Technology, Graduate Research Assistant, 1985-1992, part time
NON-ACADEMIC EXPERIENCE	Staff Engineer/Geologist, 1983 to 1986, Earth Water and Air, Inc., Minneapolis, MN
PROF. REGISTR.	
SCIENTIFIC AND PROFESSIONAL SOCIETIES	Association of Environmental Engineering and Science Professors American Chemical Society American Geophysical Union
HONORS AND AWARDS	Bennett-Lindstedt Endowed Faculty Fellow, 2013-2018, Department of Civil, Environmental, and Architectural Engineering, University of Colorado Boulder Distinguished Achievement Award, 2009, Civil, Environmental, and Architectural Engineering, University of Colorado Boulder Boulder County Pacesetter Award (Science/Health/Medicine), 2008, Boulder *Daily Camera* National Notable Achievement Award, 2006, U.S. Environmental Protection Agency, Member of the Left Hand Watershed Revitalization Team
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	**University Service** Environmental Engineering Program, director, 2012-2013 Civil, Environmental, and Architectural Engineering Department, Graduate Committee, 2012-2013 College of Engineering and Applied Science, First-Level Review Committee, 2014-present University of Colorado Boulder, Outreach and Engagement Committee, 2006-present **Professional Service** Association of Environmental Engineering and Science Professors, Newsletter Editor, 2009-2012 **National Service** U.S. Environmental Protection Agency, Science Advisory Board sub-panel on Hydraulic Fracturing Study, 2014-2016.

PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Sherwood O.A., Rogers J.D., Lackey G., Burke T.L., Osborn S.G., and Ryan J.N., 2016. Groundwater methane in relation to oil and gas development and shallow coal seams in the Denver-Julesburg Basin of Colorado. *Proceedings of the National Academy of Sciences* **113**(30), 8391-8396. Mohanty S.K., Saiers J.E., and Ryan J.N., 2016. Colloid mobilization in a fractured soil: Effect of pore water exchange between preferential flow paths and soil matrix. *Environmental Science & Technology* **50**(5), 2310-2317. Webster J.P., Kane T.J., Obrist D., Ryan J.N., and Aiken G.R., 2016. Estimating mercury emissions resulting from wildfire in the western United States. *Science of the Total Environment* **568**, 578-586. Mohanty S.K., Saiers J.E., and Ryan J.N., 2015. Colloid mobilization in a fractured soil during dry-wet cycles: Role of drying duration and flow path permeability. *Environmental Science & Technology* **49**(15), 9100-9106. Poulin B.A., Aiken G.R., Nagy K.L., Manceau A., Krabbenhoft D.P., and Ryan J.N., 2015. Mercury transformation and release differs with depth and time in a contaminated riparian soil during simulated flooding. *Geochimica et Cosmochimica Acta* **176**, 118-138. Rogers J.D., Burke T.L., Osborn S.G., and Ryan J.N., 2015. A framework for identifying organic compounds of concern in hydraulic fracturing fluids based on mobility and persistence in groundwater. *Environmental Science & Technology Letters* **2**, 158-164. Mohanty S.K., Saiers J.E., and Ryan J.N., 2014. Colloid-facilitated mobilization of metals by freeze-thaw cycles. *Environmental Science & Technology* **48**, 977-984. Poulin B.A., Ryan J.N., and Aiken G.R., 2014. The effects of iron on optical properties of dissolved organic matter. *Environmental Science & Technology* **48**, 10098-10106. Writer J.H., Antweiler R.C., Ferrer I., Ryan J.N., and Thurman E.M., 2013. In-stream attenuation of neuro-active pharmaceuticals and their metabolites. *Environmental Science & Technology* **47**(17), 9781-9790. Craven A.M., Aiken G.R., and Ryan J.N., 2012. Copper(II) binding by dissolved organic matter: Importance of the copper-to-dissolved organic matter ratio and implications for the biotic ligand model. *Environmental Science & Technology* **46**(18), 9948-9955. McCleskey R.B., Nordstrom D.K., Ryan J.N., and Ball J.W., 2012. A new method of calculating electrical conductivity with applications to natural waters. *Geochimica et Cosmochimica Acta* **77**, 369-382.
PROFESSIONAL DEVELOPMENT IN THE LAST FIVE YEARS	

Victor E. Saouma Professor

EDUCATION	Baccalaureat Serie Scientifique, Lycee Chateaubriand, Rome, 1971 B.E. Civil Engineering, American University of Beirut, 1975 M.E., Civil Engineering, Cornell University, 1977 Ph.D., Civil Engineering, Cornell University, 1980
ACADEMIC EXPERIENCE	Visiting Professor: Politecnico of Milan, Visiting Professor, Department of Structural Engineering (2003-2004); Swiss Federal Institute of Technology, Lausanne (1997-1998); Politecnico de Catalunya (Barcelona), Ecole Normale Superieure de Cachan, and Universite de Toulouse (each one month) University of Colorado – Boulder, Professor, 1995-present; Associate Professor, 1988-1995, Assistant Professor, 1984-1988 University of Pittsburg, Pittsburgh, PA, Assistant Professor, 1981-1983 Princeton Universtiy, Princeton, NJ, Research Associate, 1980-1981
NON-ACADEMIC EXPERIENCE	University of Colorado – Boulder, Director and Principal investigator of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), on Fast Hybrid Test (2006-2009)
PROFESSIONAL REGISTRATIONS	None
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Concrete Institute (ACI) International union of laboratories and experts in construction materials systems and structures (RILEM)
HONORS AND AWARDS	Fellow and Past President of the International Association of Fracture Mechanics for Concrete and Concrete Structures (IA-FraMCOs)
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	**Professional Service** ACI-ASCE Committee 447, Finite Element Analysis of Reinforce Concrete Structures RILEM QFS Committee on Size Effect and Scaling of Quasibrittle Fracture Organized the 9th International conference on fracture mechanics of concrete (IA-FraMCoS). Chair of a RILEM committee on Alkali Silica Reaction Member of the *Expanded Proactive Materials Degradation Analysis Expert Panel*(PMDA) for concrete in nuclear reactors; Nuclear Regulatory Commission, 2010- 2014 Member of the *Materials Aging and Degradation* (MAaD) External Review Committee (ORNL, Light Water Reactor Sustainability R&D Program). Member of the Scientific Committee of MACENA (France) ,*Managing confinement structures in the event of an accident*. **University Service** Chair of Search Committee

PRINCIPAL PUBLICATIONS OF LAST FIVE YEARS	Saouma, V. and Hariri-Ardebili, M. and Le Pape Y. and Balaji, R. (2016) E*ffect of Alkali-Silica Reaction on the Shear Strength of Reinforced Concrete Structural Members*. A Numerical and Statistical Study, Nuclear Engineering and Design Hariri-Ardebili, M. and Saouma, V. (2016) *Seismic Fragility Analysis of Concrete Dams; A State-of-the-Art Review*, Engineering Structures, Vol. 128, pp. 374-399 Hariri-Ardebili, M. and Saouma, V. (2016) *Probabilistic Seismic Demand Model and Intensity Measure for Concrete Dam*s, Journal of Structural Safety, Vol. 59, pp. 67-85 Hariri-Ardebili, M. and Furgani, L. and Maghella, M., and Saouma, V. (2016) *A new class of seismic damage and performance indices for arch dams via ETA method*, Engineering Structures, V. 110 pp. 145-160, Hariri-Ardebili, M. and Saouma, V. and Porter, K. (2015) *Quantification of Seismic Potential Failure Modes in Concrete Dams*, Earthquake Engineering and Structural Dynamic, Hariri-Ardebili, M. and Saouma, V. (2016) C*ollapse Fragility Curves for Concrete Dams; A Comprehensive Study,* ASCE J. of Structural Engineering, Saouma, V.E. (2015) *Applications of Fracture Mechanics to Cementitious Materials; A Personal Perspective,* in ACI SP-300 Fracture Mechanics Applications in Concrete, G.L. Cusatis Editor Saouma, V.E. and Martin, R. and Hariri-Ardebili, M. and Katayama, T.(2015) *A Mathematical Model for the Kinetics of the Alkali Silica Chemical Reaction,* Cement and Concrete Research, Vol. 68, pp. 184-195 Saouma, V. and Hariri-Ardebili, M. (2014) *A Proposed Aging Management Program for Alkali Silica Reactions in a Nuclear Power Plant* Nuclear Engineering and Structural Design, Vol 277, pp. 248-264. Saouma, V., Kang, D., Haussman, G. (2012), *A Computational Finite-Element Program for Hybrid Simulation*, Earthquake Engineering and Structural Dynamic Journal, Vol. 41, pp. 375-389.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	

Petros Sideris **Assistant Professor**

EDUCATION	Diploma, Civil Engineering, National Tech. U. of Athens, Greece, 2005. M.S., Civil Engineering, University at Buffalo – SUNY, 2008 Ph.D., Civil Engineering, University at Buffalo – SUNY, 2012 Post-doctoral Research Fellow, University at Buffalo – SUNY, 2012-13
ACADEMIC EXPERIENCE	University of Colorado at Boulder, Assistant Professor (2013 – Present) University at Buffalo – SUNY, Adjunct Lecturer (2012-13) University at Buffalo – SUNY, Graduate Research Assistant (2008-12) University at Buffalo – SUNY, SEESL Fellow (2007-08) University at Buffalo – SUNY, Graduate Teaching Assistant (2005-07)
NON-ACADEMIC EXPERIENCE	None
PROFESSIONAL REGISTRATIONS	Engineer in Training (E.I.T), Michigan, 2013 to present
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) Earthquake Engineering Research Institute (EERI) Transportation Research Board of the National Academies American Concrete Institute (ACI)
HONORS AND AWARDS	*2014 Outstanding Reviewer*, Journal of Structural Engineering, American Society of Civil Engineers (ASCE), U.S.A. *2013 Chair's Recognition Award*, Department of Civil, Structural and Environmental Engineering (CSEE), University at Buffalo, The State University of New York *2010 Liu Huixian Earthquake Engineering Scholarship Award*, US-China Earthquake Engineering Foundation, USA *2010 Paul J. Koessler Memorial Scholarship Award*, Peace Bridge Authority and ASCE Buffalo Section *Fellowship* (2007-08), Structural Engineering and Earthquake Simulation Laboratory (SEESL), University at Buffalo, The State University of New York (SUNY)
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Professional Committees: TRB Committee on Seismic Design and Performance of Bridges – AFF50 (since 2015) ASCE/SEI Seismic Effects Committee (since 2013) ASCE/SEI Performance-based Design of Structures Committee (since 2016) Reviewer for 9 peer-reviewed journals: ASCE Natural Hazards Review, Earthquake Engineering and Engineering Vibration (Springer), ASCE Journal of Bridge Engineering, ASCE Journal of Engineering Mechanics, Engineering Structures Journal, ASCE Journal of Structural Engineering, Journal of Building Engineering (Elsevier), Transportation Research Record (TRR), Journal of the Transportation Research Board, Journal of Earthquake Engineering (Taylor & Francis) University Service:

	Director, *Structures and Materials Testing Laboratory* (SMTL), University of Colorado – Boulder (since 2013, 4 years) Department Committee Work: (a) Facilities Committee, since 2014 (3 years); (b) Graduate Committee (2013-14); and (c) SESM Faculty Search Committee (2013-16)
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Nikoukalam M.T. and **Sideris, P.** (2016), "Experimental Performance Assessment of Nearly Full-Scale Reinforced Concrete Columns with Partially Debonded Longitudinal Reinforcement", *ASCE Journal of Structural Engineering* (Accepted). Nikoukalam M.T. and **Sideris, P.** (2016), "Low-Damage Post-Tensioned Segmental Bridge Columns with Flexible End Joints for Seismic Accelerated Bridge Construction", *TRR - Journal of the Transportation Research Board* (In press, DOI:10.3141/2592-17). **Sideris, P.** and Salehi, M. (2016), "A Gradient Inelastic Flexibility-Based Frame Element Formulation", *ASCE Journal of Engineering Mechanics*, 142(7), 04016039. **Sideris, P.** (2015), "Nonlinear Quasi-static Analysis of Hybrid Sliding-Rocking Bridge Columns Subjected to Lateral Loading", *Engineering Structures Journal*, 101, 125-137. **Sideris, P.**, Aref, A. and Filiatrault, A. (2015), "Experimental Seismic Performance of a Hybrid Sliding-Rocking Bridge for Various Specimen Configurations and Seismic Loading Conditions", *ASCE Journal of Bridge Engineering*, 20(11), 04015009. **Sideris, P.**, Aref, A. and Filiatrault, A. (2014), "Effects of Anchorage Hardware on the Cyclic Tensile Response of Unbonded Monostrands", *PCI Journal*, 59(6), 60-77. **Sideris, P.**, Aref, A. and Filiatrault, A. (2014), "Quasi-Static Cyclic Testing of a Large-Scale Hybrid Sliding-Rocking Segmental Column with Slip-Dominant Joints", *ASCE Journal of Bridge Engineering*, 19(10), 04014036. **Sideris, P.**, Aref, A. and Filiatrault, A. (2014), "Large-scale Seismic Testing of a Hybrid Sliding-Rocking Post-Tensioned Segmental Bridge System", *ASCE Journal of Structural Engineering*, 140(6), 04014025. **Sideris, P.** and Filiatrault, A. (2014), "Seismic Response of Squat Rigid Bodies on Inclined Planes with Rigid Boundaries", *ASCE Journal of Engineering Mechanics*, 140(1): 149–158.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Faculty Teaching Excellence Program, University of Colorado – Boulder, Fall 2015 2012 Future Faculty Workshop, Strategies for Effective Teaching, Office of the Vice Provost for Faculty Affairs & the Teaching & Learning Center, University at Buffalo, The State University of New York

JoAnn Silverstein **Professor**

EDUCATION	BA, Psychology, Stanford University, 1967 BS, Civil Engineering, University of California, Davis, 1977 MS, Civil Engineering, University of California, Davis, 1980 Ph.D., Civil Engineering, University of California, Davis,, 1982
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 1998 – present; Associate Professor, 1989-1997; Assistant Professor, 1982-1988; Founding Faculty Director Sustainable By Design Residential Academic Program, 2011-2014; Director, Program in Environmental Design, 2012-2015; Chair, Dept. Civil, Environmental and Architectural Engineering, 2002-2010; Board of Directors, Center of the American West, 2015 – present. University of California, Davis, Graduate Research Assistant, 1980 – 1982.
NON-ACADEMIC EXPERIENCE	California Department of Water Resources, State Water Project Division of O & M: Intern, 1976-1977; Assistant Engineer, 1978-1980. Applied Environmental Services, consultant, 1996 – 2000.
PROFESSIONAL REGISTRATIONS	P.E., Civil Engineering, Colorado, #26151, 1988 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Academy of Environmental Engineers and Scientists ((AAEES) American Society of Civil Engineers (ASCE) American Water Works Association Association of Environmental Engineering & Science Professors (AEESP) International Water Association (IWA) Society of Women Engineers (SWE) Water Environment Federation (WEF) Tau Beta Pi, Chi Epsilon
HONORS AND AWARDS	Distinguished Service Award, AEESP, 1997 Distinguished Engineering Educator, SWE, 2000 Keynote Speaker, AEESP National Meeting, 2014 Eminence Member, AAEES, 2006 CU-LEAD Alliance, Faculty Appreciation Award, 2006
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	AAEES: Eminence Member Selection Committee, 2005 – present. External Promotion and Tenure Reviews (~ 3 per year for faculty at US universities) **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Personnel Committee. 1998-present. Chair of three Primary Unit Evaluation Committees for tenure and promotion. Faculty mentor to two assistant professors. Awards Committee. Chair. 2015-16. <u>College of Engineering at the University of Colorado - Boulder</u> <u>Boulder Campus</u>. Program Review: Environmental Design, Theater and Dance Department (2011 and 2016. Director, Program in Environmental Design, 2012-2015

	Office of Diversity, Equity and Community Engagement (ODECE), Faculty Advisory Council, 2011-present.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Kohler, L.E., J. Silverstein, B. Rajagopalan (2016) Predicting Life Cycle Failures of On-Site Wastewater Treatment Systems Using Generalized Additive Models, Environ. Eng. Sci., 33(2):112-124. Kohler, L.E., J. Silverstein, B. Rajagopalan (2016) Risk-Cost Estimation of On-site Wastewater Treatment Systems Using Extreme Value Analysis, Water Environment Research, in press. Kohler, L.E., J. Silverstein, B. Rajagopalan (2016) Modeling On-site Wasewater Treatment System Performance Fragility to Hydroclimate Stressors, Wat. Sci. Technol., in press. Suchetana, B., B. Rajagopalan, J. Silverstein (2016) Hierarchical Modeling Approach to Evaluation of Spatial and Temporal Variability of Wastewater Treatment Compliance with Biochemical Oxygen Demand, Total Suspended Solids, and Ammonia Limits in the United States, Environ. Eng. Sci., 33(7):514-524. Weirich, S.R.,* J. Silverstein, and B. Rajagopalan, (2015) Resilience of Secondary Wastewater Treatment Plants: Prior Performance is Predictive of Future Process Failure and Recovery Time. Environ. Eng. Sci. 32(3):222-231. Weirich, S.R.,* J. Silverstein, and B. Rajagopalan, (2015) Simulation of effluent BOD and ammonia for increasingly decentralized networks of wastewater treatment facilities. Environ. Eng. Sci. 32(3):232-239 ***Weirich, S. R.,* Silverstein, J., & Rajagopalan, B. (2011). Effect of average flow and capacity utilization on effluent water quality from US municipal wastewater treatment facilities. Water Research, 45(14), 4279-4286. Doi:10.1016/j.watres.2011.06.002***. Yacob, T.*, Pandey, S.,* Silverstein, J. Rajaram, H. (2013) Soluble Microbial Products Decrease Pyrite Oxidation by Ferric Iron at pH < 2, Environmental Science & Technology, 47(15):8658-8665, 2013.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Univ. Colorado, Boulder, Peak-to-Peak Workshops on integration of sustainability into undergraduate curriculum, 2012 – 2013. Center of the American West Workshop on Urban Sustainability in Western Cities, Portland, OR, September 2015. Center of the American West, Workshop on Integration of Agriculture, Water Resources, and Public Lands, Fresno, CA, September 2016.

Jeong-Hoon Song Assistant Professor

EDUCATION	BS, Civil Engineering, Yonsei University, 2001 MS, Civil Engineering, Yonsei University, 2003 Ph.D., Theoretical and Applied Mechanics, Northwestern University, 2008
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assistant Professor, 2014-present University of South Carolina: Assistant Professor, 2011-2014 Northwestern University, Post-doctoral Fellow, 2008-201 Northwestern University, Research Assistant, 2004-2008
NON-ACADEMIC EXPERIENCE	Naval Research Laboratory, Faculty Research Fellow, summer 2014-2016
PROFESSIONAL REGISTRATIONS	None
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) American Society of Mechanical Engineers (ASME) US Association for Computational Mechanics (USACM) International Association for Computational Mechanics (IACM)
HONORS AND AWARDS	ONR Faculty Research Fellowship (2014-2016): Office of Naval Research
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Committee Member (2013-Present): Computational Mechanics Committee; technical committee in Engineering Mechanics Institute (EMI) at American Society of Civil Engineers (ASCE) Corresponding Guest Editor (2015-2016): Special Issue on “Computational modeling of material deterioration at various length scales”, International Journal of Fracture. Guest Editor: Special Issue on “Experimental Testing and Computational Modeling of Dynamic Fracture”, International Journal of Impact Engineering, 87: 1-212 (2016). Member of Editorial Board (2014-Present): International Journal of Modern Mechanics Member of Editorial Board (2012-Present): Journal of Computational Engineering **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Graduate Committee. 2014-present.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	K.C. Hoang, Y. Fu, and J.H. Song, An hp-proper orthogonal decomposition-moving least squares approach for molecular dynamics simulation, Computer Methods in Applied Mechanics and Engineering, 298: 548-575 (2016). J. Lua, T. Zhang, E. Fang and J.H. Song, “Explicit phantom paired shell element approach for crack branching and impact damage prediction of aluminum structures”, International Journal of Impact Engineering, 87:28–43 (2016).

	Y. Fu, J.G. Michopoulos and J.H. Song, "Dynamic response of polyethylene polymer nanocomposites to shock wave loading", Journal of Polymer Science, Part B: Polymer Physics, 53: 1292-1302 (2015). Y. Fu, J.G. Michopolous and J.H. Song, "Coarse-grained molecular dynamics simulations of epoxy resin during the curing process", Computational Materials Science, 107: 24-32 (2015). Y. Fu and J.H. Song, "Heat flux expressions that satisfy the conservation laws in atomistic system involving multibody potentials", Journal of Computational Physics, 294: 191–207 (2015). Y. Fu and J.H. Song, "Large deformation mechanism of glassy polyethyelene polymer nanocomposites: coarse grain molecular dynamics study", Computational Materials Science, 96: 485-494 (2015). A. Tabarraeia, S. Shadaloua and J.H. Song, "Mechanical properties of Graphene nanoribbons with disordered edges", Computational Materials Science, 96: 10-19 (2015). A. Tabarraie, X. Wang, A. Sadeghirad and J.H. Song, "An enhanced bridging domain method for linking atomistic and continuum domains", Finite Elements in Analysis and Design, 92:36-49 (2014). Y. Fu and J.H. Song, "On computing stress in polymer systems involving multi-body potentials from molecular dynamics simulation", Journal of Chemical Physics, 141: 054108 (2014). J.H. Song and Y.C. Yoon, "Multiscale failure analysis with coarse-grained micro cracks and damage", Theoretical and Applied Fracture Mechanics, 72: 100-109 (2014). Y.C. Yoon and J.H. Song, "Extended particle difference method for moving boundary problems", Computational Mechanics, 54:723–743 (2014). Y.C. Yoon and J.H. Song, "Extended particle difference method for weak and strong discontinuity problems: Part II. Formulations and applications for various interfacial singularity problems", Computational Mechanics, 53:1105-1128 (2014). Y.C. Yoon and J.H. Song, "Extended particle difference method for weak and strong discontinuity problems: Part I. Derivation of the extended particle derivative approximation for the representation of weak and strong discontinuities", Computational Mechanics, 53:1087-1103 (2014). A. Tabarraei, J.H. Song and H. Waisman, "Two-scale approach for modeling adiabatic shear band propagation under impact loads", International Journal for Multiscale Computational Engineering, 11: 543-563 (2013).
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	None

R. Scott Summers Professor

EDUCATION	B.S., Civil Engineering, University of Cincinnati, 1975 M.S., Environmental Engineering, University of Cincinnati, 1977 Ph.D., Environmental Engineering & Science, Stanford University, 1986
ACADEMIC EXPERIENCE	University of Colorado-Boulder: Professor, 1998-present; Director, Environmental Engineering Program, 2013-present; Program Coordinator, Graduate Environmental Engineering Program, 2000-2010, 2012- 2014; Director, DeRISK Center, 2014-present, Director, Center for Drinking Water Optimization, 1997-2004; University of Cincinnati: Associate Professor, 1993-1998; Assistant Professor, 1988-1993; Program Coordinator, Water, Waste Water and Hazardous Waste Program ,1988-1998; University of Crete, Greece, Visiting Fulbright Professor, (sabbatical), 1995 Universitat Karlsruhe, Germany, Research Associate (post-doctoral fellow), 1986-1988 Stanford University, Research Assistant, 1979-1985 University of Cincinnati, Research Assistant, 1975-1977
NON-ACADEMIC EXPERIENCE	U.S. EPA, Municipal Environmental Research Laboratory, Cincinnati, OH; Visiting Research Scientist, (sabbatical), 1996; Project Engineer, 1977-1979 Summers & Hooper, Inc., Technical Director (part time), 1995-2000
PROFESSIONAL REGISTRATIONS	EIT, Ohio, 1975.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	Association of Environmental Engineering & Science Professors (AEESP) American Water Works Association (AWWA) American Society of Civil Engineers (ASCE)
HONORS AND AWARDS	Water Quality Division Best Paper Award, Journal AWWA, 2016 A.P. Black Award, American Water Works Association, 2013 CEAE Department, University of Colorado; Service Award, 2011; Student's Favorite Professor Award, 2010; Teaching Award, 2009; Research Award, 2007 Academic Achievement Award, MS or PhD advisor, American Water Works Association, 1993, 1995, 1996 (2), 1998, 1999, 2000
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	American Water Works Association: Water Science and Research Division, 2004-2010 Trustee; Water Quality and Technology Conference Planning Committee, 2007-2010, Activated Carbon Committee, 1994-current; Biological Drinking Water Treatment Committee, 2000- current; Biotreatment Symposium Organizing Committee, 2013; VOC Workshop Organizing Committee, 2011

	University Service Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Personnel Committee, 1998-present; Graduate Committee, 2000-2003, Chair 2008-2012; Environmental Engineering Graduate Program Coordinator, 2000-2011, 2013-present Environmental Engineering (EVEN) cross-disciplinary degree program, 1998- present; Director. 2014 - present College of Engineering at the University of Colorado - Boulder Undergraduate Education Council. 2014-present
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Hohner, A. K., Cawley, K., Oropeza, J., Summers, R. S., & Rosario-Ortiz, F. L. (2016). Drinking water treatment response following a Colorado wildfire. *Water Research*, *105*, 187-198. Samson, C. C., Rajagopalan, B., & Summers, R. S. (2016). Modeling Source Water TOC Using Hydroclimate Variables and Local Polynomial Regression. *Environmental Science & Technology*, *50*(8), 4413-4421. Kempisty, D. M., & Summers, R. S. (2016). Effect of Influent Groundwater Quality on Adsorption of Low Concentrations of 1, 2 Dichloroethane by Granular Activated Carbon. *Journal of Environmental Engineering*, *142* (12), 04016064. Shimabuku, K. K., Kearns, J. P., Martinez, J. E., Mahoney, R. B., Moreno-Vasquez, L., & Summers, R. S. (2016). Biochar sorbents for sulfamethoxazole removal from surface water, stormwater, and wastewater effluent. *Water Research*, *96*, 236-245. Thompson, K. A., Shimabuku, K. K., Kearns, J. P., Knappe, D. R., Summers, R. S., & Cook, S. M. (2016). Environmental Comparison of Biochar and Activated Carbon for Tertiary Wastewater Treatment. *Environmental Science & Technology*, *50*(20), 11253-11262. Summers, R.S., Finau-Starkey, L. (2016), Work-in-Progress – Development of a student-based mentorship program for first-year environmental engineering students, Proceedings First-Year Engineering Experience (FYEE) Conference, Columbus, OH. Saunders, J.F., Hohner, A.K.., Summers, R.S., Rosario-Ortiz, F.L., (2015) "Regulating Chlorophyll a to Control DBP Precursors in Water Supply Reservoirs," *J. Amer. Water Works Assoc*., http://dx.doi.org/10.5942/jawwa.2015.107.0153, 107 (11) E603-E612. Kennedy, A.M., Summers, R.S., (2015) Effect of DOM Size on Organic Micropollutant Adsorption by GAC, *Environmental Science & Technology*., **DOI:** 10.1021/acs.est.5b0041149 (11), pp 6617–6624.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Association of Environmental Engineering and Science Professors (AEESP) Conference, Department Chairs and Directors Workshop, 2013. First-Year Engineering Experience (FYEE) Conference, July 31 – August 2, 2016, Columbus, OH

Michael E. Walker **Instructor**

EDUCATION	BS, Chemistry, University of Illinois, 2004 Ph.D., Chemical Engineering, Illinois Institute of Technology, 2012
ACADEMIC EXPERIENCE	University of Colorado Boulder: Instructor, 2014 – present Northwestern University, Evanston IL, Postdoctoral Fellow, 2012-2014 Illinois Institute of Technology, TA/RA, 2007-2012, part time
NON-ACADEMIC EXPERIENCE	United States Gypsum, Libertyville, IL, Technical Staff L1, 2005-2006 Valent Biosciences Corp., Long Grove, IL, Assistant Tech., fall 2004
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Chemical Society (ACS) American Institute of Chemical Engineers (AIChE) Association of Environmental Engineering & Science Professors (AEESP)
HONORS AND AWARDS	Big Dog Award - Food & Beverage Environmental Conference 2014 ChBE Departmental Excellence in Teaching Award (TA of the Year) 2010 ChBE Departmental Excellence in Teaching Award (TA of the Year) 2009 ChBE Departmental Excellence in Teaching Award (TA of the Year) 2008 ARCS Scholarship Award 2011 ARCS Scholarship Award 2010
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	American Institute of Chemical Engineers (AIChE). Environmental Division: Leg & Reg co-chair (2014-16); 2nd Vice Chair of programming for Environmental Engineering: Midwest Regional Conference (2015); Chair – Energy, Sustainability and the Environment: Midwest Regional Conference (2014) **University Service** Civil Environmental and Architectural Engineering (CEAE) Computing Committee. 2016-present Environmental Engineering (EVEN) Curriculum Committee. 2015-present College of Engineering at the University of Colorado - Boulder Energy Engineering Minor Committee. 2015-present
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	**Publications and Technical Reports** Briam, R.B.; Walker, M.E.; Masanet, E. (2015). A Comparison of Product-based Energy Intensity Metrics for Cheese and Whey Processing. Journal of Food Engineering, 151, 25-33. Walker, M.E.; Arnold, C.S.; Lettieri, D.J., et al. (2014). Energy Intensity Comparisons of Concentrated Food Products. *Environmental Science & Technology*, 48(20), 12370-12377. Walker, M.E., Lettieri, D.J., Romanin, V., et al. (2013). Establish GHG Emissions Efficiency Benchmarks for Covered Industrial Sectors. Prepared for the California Air Resources Board and the California

	Environmental Protection Agency by Northwestern University, University of California, Berkeley, and Ecofys. June 30, 2013. Walker, M.E.; Lv, Z.; Masanet, E. (2013). Industrial Steam Systems and the Energy-Water Nexus. *Environmental Science & Technology*, 47(22), 13060-13067. Masanet, E.; Walker, M.E. (2013). Energy-Water Efficiency and U.S. Industrial Steam. *AIChE Journal (Cover Article)*, 59(7), 2268-2274. Walker, M.E.; Theregowda, R.B.; Safari, I., et al. (2013). Utilization of Municipal Wastewater for Cooling in Thermoelectric Power Plants: Evaluation of the Combined Cost of Makeup Water Treatment and Increased Condenser Fouling. *Energy*, 60, 139-147. Safari, I.; Walker, M.E.; Abbasian, J., et al. (2013). Utilization of Municipal Wastewater for Cooling in Thermoelectric Power Plants. Fuel, 111, 103-113. Walker, M.E.; Safari, I.; Theregowda, R.B., et al. (2012). Economic Impact of Condenser Fouling in Existing Thermoelectric Power Plants. *Energy*, 44, 429-437. Hsieh, M.K.; Walker, M.E.; Safari, I., et al. (2012). Ammonia Stripping in Open-Recirculating Cooling Water Systems. Environmental Progress & Sustainable Energy, 32(3), 489-495. Walker, M.E.; Abbasian, J.; Chmielewski, D.J.; Castaldi, M.J. (2011). Dry Gasification Oxy-Combustion Power Cycle. *Energy & Fuels*, 25, 2258-2266 **Presentations** Grand Challenges Facing the Implementation of Carbon Cap-and-Trade Policy for Complex Manufacturing Industries. Food & Beverage Environmental Conference: Napa, California – March, 2014. Industrial Boiler Systems and the Energy-Water Nexus. AIChE Annual Meeting: San Francisco, California – November, 2013. Economic Evaluation of Freshwater Conservation Strategies for Thermoelectric Power Plants. AIChE Annual Meeting: San Francisco, California – November, 2013 Development of Product-Based Energy Intensity Metrics for the California Food Industry. Carbon Management Technology Conference: Alexandria, Virginia – October, 2013.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Food & Beverage Environmental Conference. March, 2014. AIChE Annual Meeting. November, 2013. Carbon Management and Technology Conference. October, 2013.

Yunping Xi Professor

EDUCATION	BS, Civil Engineering, Beijing Institute of Civil Engineering and Architecture, 1982 MS, Structural Engineering, Central Research Institute of Building and Construction, Beijing, 1985 Ph.D., Structural Engineering, Northwestern University, 1991
ACADEMIC EXPERIENCE	University of Colorado – Boulder, Professor, 2005-present; Associate Professor, 2000-2005; Assistant Professor, 1997-2000 Drexel University, Assistant Professor, 1993-1997 Northwestern University, Research Scientist, 1991-1993; Visiting Scholar, 1987-1988
NON-ACADEMIC EXPERIENCE	Beijing Central Research Institute of Building and Construction, Structural Engineer 1985-1987 Beijing Design Institute of Building and Construction, 1982-1983
PROFESSIONAL REGISTRATIONS	None
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) International Association on Concrete Creep (IA-Concreep) American Concrete Institute (ACI)
HONORS AND AWARDS	2014 *Chang Jiang Chaired Professor*, Department of Education, China. 2010 *Kwang-Hua Chair Professor* at Tongji University, China. A recipient of *2010 Faculty Fellowship* at University of Colorado at Boulder. Research Development Award, Department of Civil, Environmental, and Architectural Engineering (CVEN), University of Colorado – Boulder, 2004. Young Researcher's Award, CVEN, University of Colorado – Boulder, 1998-1999 Faculty Advisor for Drexel Teams in American Concrete Institute (ACI) Beam Competition, First Prize for highest ultimate load and First Prize for best prediction, 1994
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	- The chair of Experimental Analysis and Instrumentation (EA&I) Committee, ASCE Engineering Mechanics Institute (EMI) - University Administrator of Colorado Local Technical Assistance Program - Members of the editorial board of international journals "*Computers in Concrete*", "*Magazine of Concrete Research"*, and "*Journal of Sustainable Cement Based Materials"*. **University Service** - A member of First Level Review Committee of College of Engineering (2012 – 2015).
PRINCIPAL PUBLICATIONS OF	1. Musiket, K., Vernerey, F., and Xi, Y. (2016) "Numeral Modeling of Fracture Failure of Recycled Aggregate Concrete Beams under High

LAST FIVE YEARS	Loading Rates", *International Journal of Fracture*, doi:10.1007/s10704-016-0145-3. 2. Jiang, Z., Huang, Q.H., Xi, Y., Gu, X.L., Zhang, W.P. (2016) "Experimental Study of Diffusivity of Interfacial Transition Zone between Cement Paste and Aggregate", *J. of Materials for Civil Engineering, ASCE*, 28(10): 04016109; DOI: 10.1061/(ASCE)MT.1943-5533.0001637. 3. Homan, L., Ababneh, A., and Xi, Y. (2016) "The Effect of Moisture Transport on Chloride Penetration in Concrete", *Construction and Building Materials*, 125, 1189-1195. 4. Na, O., and Xi, Y. (2016) "Mechanical and Durability Properties of Portland Cement Insulation Mortar with Rubber Powder from Waste Tires", *Journal of Material Cycles and Waste Management*, DOI 10.1007/s10163-016-0475-2. 5. Na, O., Ou, E., Xi, Y., and Saouma, V. (2016) "The Effects of Alkali-Silica Reaction on Mechanical Properties of Concrete with Three Different Types of Reactive Aggregates", *Structural Concrete*, DOI: 10.1002/suco.201400062. 6. Musiket, K., Rosendahl, M., and Xi, Y. (2016) "Fracture of Recycled Aggregate Concrete under High Loading Rates", *J. of Material in Civil Eng., ASCE*, 10.1061/(ASCE)MT.1943-5533.0001513 , 04016018. 7. Zhang, W.P., Tong, F., Gu, X.L., Xi, Y. (2015) "Study on Moisture Transport in Concrete in Atmospheric Environment", *Computers and Concrete*, 16(5), 775-793. 8. Zhang, W.P., Min, H.G., Gu, X.L., Xi, Y., Xing. Y.S. (2015) "Mesoscale Model for Thermal Conductivity of Concrete", Construction and Building Materials, 98, 8-16. 9. Bai, Y., Harajli, A., Xi, Y. (2015) "Analytical Solutions of Ionic Diffusion and Heat Conduction In Multi-Layered Porous Media", *Journal of Applied Mathematics*, Vol. 2015, Article ID 208914, 11 pages, doi:10.1155/2015/208914. 10. Damrongwiriyanupap, N., Limkatanyu, S., and Xi, Y. (2015) "A Thermo-Hygro coupled Model for Chloride Penetration in Concrete Structures", *Advances in Materials Science and Engineering*, vol. 2015, Article ID 682940, 10 pages, doi:10.1155/2015/682940.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	- Mastering the subsurface through technology innovation and collaboration: carbon storage and oil and Natural gas technologies review meeting, Aug. 16-18, Pittsburgh, PA. - Annual meeting of engineering mechanics institute of ASCE, May 22, Nashville, TN. - MAMNA 2016, March 21, Johns Hopkins.

Yida Zhang Assistant Professor

EDUCATION	BS, Civil Engineering, Zhejiang University, 2010 MS, Civil Engineering, Louisiana State University, 2012 Ph.D., Civil Engineering, Northwestern University, 2016
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assistant Professor, 2016 – present;
NON-ACADEMIC EXPERIENCE	N/A
PROFESSIONAL REGISTRATIONS	N/A
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) American Rock Mechanics Association (ARMA)
HONORS AND AWARDS	**Terminal Year Fellowship**, Northwestern University, 2016 **Walter P. Murphy Fellowship**, Northwestern University, 2013 **Outstanding Undergraduate Final Project**, Zhejiang University, 2010 **First Prize of Chinese Physics Olympiad**, China, 2005
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	American Society of Civil Engineers (ASCE). Technical board, Unsaturated Soils (2016-present)
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	<u>Publications</u> Zhang, Y.D. & Buscarnera, G. (2017) Rate-dependent breakage mechanics: a continuum theory accounting for the fracture kinetics of minerals. Accepted, *Géotechnique*. Gao, S., Zhang, Y.D., Sonta, A. & Buscarnera, G. (2016) Evolution of water retention characteristics of granular material subjected to grain crushing. *Journal of Geotechnical and Geoenvironmental Engineering* 142 (9). Zhang, Y.D., Buscarnera, G. & Einav, I. (2015) Grainsize dependence of yielding in granular soils interpreted using fracture mechanics, breakage mechanics, and Weibull statistics. *Géotechnique* 66(2), 149-160. Zhang, Y.D. & Buscarnera, G. (2015) Implicit Integration under Mixed Controls of a Breakage Model for Unsaturated Crushable Soils. *International Journal for Numerical and Analytical Methods in Geomechanics*. Published online, DOI: 10.1002/nag.2431. Zhang, Y.D. & Buscarnera, G. (2015) Prediction of breakage-induced couplings in unsaturated granular soils. *Géotechnique* 65(2), 135-140. Zhang, Y.D. & Buscarnera, G. (2014). Grainsize dependence of clastic yielding in unsaturated granular soils. *Granular Matter* 16(4), 469-483. Voyiadjis, G.Z., Faghihi, D. & Zhang, Y.D. (2014) A theory for grain boundaries with strain-gradient plasticity. *International Journal of Solids and Structures* 51, 1872-1889.

	<u>Presentations</u> EMI 2016 & PMC 2016, "*Grain size effect in the comminution of granular materials*" May, 2016, Nashville, TN. 49th US Rock Mechanics/Geomechanics Symposium, "*Constitutive couplings in unsaturated granular media with crushable grains*" July, 2015, San Francisco, CA. 17th U.S. National Congress on Theoretical & Applied Mechanics, "*Computational aspects of a hydro-mechanical model for crushable granular soils*", June, 2014, East Lansing, MI. 2013 Conference of the ASCE Engineering Mechanics Institute, "*Understanding hydro-mechanical coupling in brittle unsaturated granular matter*", Aug. 2013, Evanston, IL
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	N/A

Dobroslav Znidarcic Professor

EDUCATION	BS, Civil Engineering, University of Zagreb, Croatia, 1972 MS, Civil Engineering, University of Zagreb, Croatia, 1978 Ph.D., Civil Engineering, University of Colorado Boulder, 1982
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2006 – present; Associate Professor, 1992-2006; Assistant Professor, 1985-1992; University of Zagreb, Croatia, Docent 1983-1984 Purdue University, Visiting Assistant Professor, 1984-1985 University of Zagreb, Fulbright Scholar (sabbatical), 2001-2002 University of Colorado, Boulder, Research Assistant 1980-1982 University of Zagreb, Research and Scientific Assistant, 1972-1979
NON-ACADEMIC EXPERIENCE	ISMES Bergamo, Italy, Visiting Scientist (sabbatical) 1993-1994 Geoexpert Zagreb, Croatia, Head of the field laboratory, 1974-1977
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Civil Engineers (ASCE) Croatian Society for Soil Mechanics and Geotechnical Engineering (HGD) International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) American Society for Testing and Materials (ASTM)
HONORS AND AWARDS	Fulbright Scholar, 2001-2002. Suklje Lecturer, Slovenian Geotechnical Society, Strunjan 2007 Nonveiller Lecturer, Croatian Geotechnical Society, Zagreb, 2012 Ardaman-Wissa Lecturer, University of Florida, Gainesville, 2016
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Modeling Aspects of Tailings Disposal Facility Design – Prediction of Storage Capacity, Short Course Delivered at the - Tailings and Mine Waste conferences, US and Canada with G. Gjerapic and D. vanZyl, 2012-2016. **University Service** Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Operations Committee Chair, 2011- Transfer Students Evaluator, 2011- University of Colorado – Boulder Campus Graduate School Fellowship Committee, member, 2012-2015 Graduate School Dissertation Completion Fellowship Committee, member, 2012-2015
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Lee, J. and Znidarcic, D., 2013, Flow Pump System for Unsaturated Soils: Measurement of Suction Response and the Soil–Water Retention Curve, Geotechnical Testing Journal, Vol. 36, No. 5, 12 pp. Estepho, M., van Zyl, D., Znidarcic, D., and Revington, A., 2013, Seepage Induced Consolidation Testing of Mature Fine Tailings, Tailings and Mine Waste '13 conference proceedings, November 3-6, Banff, AB, Canada, ISBN: 978-1-55195-326-7, pp.101-109.

	Brink, N., Kim, H., and Znidarcic, D., 2013, Consolidation Modelling for Geotextile Tubes Filled with Fine-Grained Materials, Proceedings of the GeoAfrica 2013 Conference, Accra, 2013. 18-20 November 2013, Accra, Ghana, CD-ROM.pp.10. Treinen, J.M., Cooke, R., and Znidarcic, D., 2014, A discussion of the critical drivers for tailings beach flows, Proceedings of the 17th International Seminar on Paste and Thickened Tailings, June 9-12, 2014 Vancouver, Canada, Richard Jewell, Andy Fourie, Patrick Sean Wells, and Dirk van Zyl eds., InfoMine Inc., June 2014 ISBN 978-0-9917905-3-1, pp. 19-30. Gjerapic, G., Bronson, B.R., Johnson, J.M. and Znidarcic, D., 2014, Embankment Stability on Soft Soil Foundations, Tailings and Mine Waste '14 conference proceedings, October 6-8, Keystone, CO, Brink, N., Kim, H., and Znidarcic, D., 2015, Numerical Modeling Procedures for Consolidation of Fine-Grained Materials in Geotextile Tubes, Proceedings of the Geosynthetics 2015 Conference, Portland, OR, 15-18 February 2015, pp.10. Znidarcic, D., 2015, If it creeps, does it matter? Tailings and Mine Waste '15 conference proceedings, October 25-28, Vancouver, BC, Canada, pp.229-235. Znidarcic, D., Adkins, D., Utting, L. and Catling, M., 2015, Rheomax® ETD technology, a laboratory study of application performance and associated geotechnical characteristics for polymer assisted tailings deposition of oil sands MFT, Tailings and Mine Waste '15 conference proceedings, October 25-28, Vancouver, BC, Canada, pp.508-520. Fourie, A., and Znidarcic, D., 2016, Optimising the Thin-lift Deposition of Thickened Tailings, Tailings and Mine Waste '16 conference proceedings, October 2-5, Keystone, CO. Gjerapic, G., Malgesini, M., Johnson, J.M., and Znidarcic, D., 2016, Use of Pore Water Pressure Measurements to Evaluate Risk to Tailings Stability, Tailings and Mine Waste '16 conference proceedings, October 2-5, Keystone, CO. Znidarcic, D., Van Zyl, D., Mario Ramirez, M., Mittal K., and Kaminsky, H., 2016, Consolidation Characteristics of Flocculated MFT – Experimental Column and SICT data, International Oil Sands Tailings conference proceedings, December 4-7, Lake Louise, AB, Canada, pp. Al-Yaqoub, T.H. Parol, J. and Znidarcic, D., 2017, Experimental investigation of volume change behavior of swelling soil, Applied Clay Science, Vol. 137, pp. 22-29
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Tailings and Mine Waste conferences 2011, 2012, 2013, 2014, 2015 and 2016. International Oil Sands Tailings Conference, 2016.

Building Systems Faculty Resumes follow, in alphabetical order

(these faculty typically devote about 5% of their time to civil engineering; see Table 6-2)

Gregor P. Henze **Professor**

EDUCATION	Technical University of Berlin, Mechanical Engineering, B.S. 1989 Oregon State University, Mechanical Engineering, M.S. 1991 Technical University of Berlin, Mechanical Engineering, Dipl.-Ing. 1992 University of Colorado Boulder, Civil Engineering, Ph.D. 1995
ACADEMIC EXPERIENCE	2014-2015, Visiting Professor, Universidad de Sevilla, Spain 2013 to present, Joint Professor, National Renewable Energy Laboratory 2008 to present, Professor, University of Colorado Boulder 1999-2008, Assistant/Assoc. Professor, University of Nebraska-Lincoln
NON-ACADEMIC EXPERIENCE	2005-2006, Visiting Scientist, Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany 2005, Visiting Scientist, Siemens Building Technologies, Zug, CH 1996-1999, Energy Engineering Manager, Johnson Controls, Germany
PROFESSIONAL REGISTRATIONS	HBDP, High-Performance Building Design Professional, 2006 to present. P.E., Mechanical Engineering, Nebraska, 2004 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) American Society of Civil Engineers (ASCE) International Building Performance Simulation Association (IBPSA)
HONORS AND AWARDS	University of Colorado AREN Appreciation Award 2015; University of Colorado CEAE Department Service Award 2014 Endowed Lewis-Worcester Faculty Fellowship 2014-2018 Architectural Engineering Institute (AEI) 2013 Best Paper Award University of Colorado CEAE Distinguished Achievement Award 2012 Colorado Cleantech Industry Association Research and Commercialization Award 2011 University of Colorado CEAE Research Development Award 2011
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	Chair for Workshop on Intelligent Building Operations, Purdue University, June 2016; U of Colorado 2013; Concordia U. 2011. Editorial Board Member for Journal of Building Performance Simulation since 2015. Associate Editor for Journal of Architectural Engineering since 2015 Associate Editor for Renewable Energy in the topical area of "Low Energy Architecture and Buildings" for 2014-2015. Renewable and Sustainable Energy Institute (RASEI) Fellow and Executive Committee Member since 2010 American Society of Mechanical Engineers (ASME) Solar Energy Division Technical Committee Chair for Conservation and Solar Buildings for 2008-2014. Associate Editor for Journal of Solar Energy Engineering in topical area of "Conservation and Solar Buildings" for 2008-2014. Member of ASHRAE committee charged with developing a certification program on Sustainable Building Design and Operation.

	University Service Dept. of Civil, Environmental, & Architectural Engineering (CEAE) Curriculum Committee, 2015 to present. Executive Committee, 2012-2014. AREN Faculty Director, 2012-2014. Associate Chair, 2010-2012. College of Engineering at the University of Colorado - Boulder Dean Search Committee, 2015-2016. Energy Engineering Minor Committee, 2013 to present.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	Giuliani, M., G.P. Henze, and A.R. Florita (2016) „Modeling and Calibration of a High-Mass Historic Building for Energy and Comfort Assessment." Energy and Buildings, 116, 434-448. Patteeuw, D., G.P. Henze, and L. Helsen (2016), "Comparison of load shifting incentives for low-energy buildings with heat pumps to attain grid flexibility benefits." Applied Energy, 167, 80-92. Henze, G.P., Pless, S., Petersen, A., Long, N., and Scambos, A. T. (2015). Control limits for building energy end use based on frequency analysis and quantile regression. Energy Efficiency, 8(6), 1077-1092 Pavlak, G.S., Henze, G.P., and Cushing, V. J. (2015). Evaluating synergistic effect of optimally controlling commercial building thermal mass portfolios. Energy, 84, 161-176. Harmer, L.C. and Henze, G.P. (2015). Building Commissioning Using Calibrated Energy Models. Energy and Buildings, 92, 2014-2015. Henze, G.P., Pavlak, G.S., Florita, A.R., Dodier, R.H., and Hirsch, A.I. (2015). An energy signal tool for decision support in building energy systems. Applied Energy, 138, 51-70. Zhao, P., Henze, G.P., Brandemuehl, M.J., Cushing, V.J., and Plamp, S. (2015). Dynamic frequency regulation resources of commercial buildings through combined building system resources using a supervisory control methodology. Energy and Buildings, 86, 137-150. Pavlak, G.S., Henze, G.P., and Cushing, V.J. (2014). Optimizing commercial building participation in energy and ancillary service markets. Energy and Buildings, 81, 115-126. Pavlak, G.S., Florita, A.R., Henze, G.P., and Rajagopalan, B. (2013). Comparison of Traditional and Bayesian Calibration Techniques for Gray-Box Modeling. Journal of Architectural Engineering, 20(2). Tanner, R.A., and Henze, G.P. (2014). Stochastic control optimization for a mixed mode building considering occupant window opening behaviour. Journal of Building Performance Simulation, 7(6), 427-44.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Co-Chair for Workshop on Intelligent Building Operations, West Lafayette, IN, Purdue University, June 2016. Co-Chair for Workshop on Building-to-Grid Integration, Universidad de Sevilla, Spain, June 2015. Chair for Workshop on Intelligent Building Operations, University of Colorado Boulder, June 2013. Chair for Workshop on Model Predictive Control in Buildings, Concordia University, Montreal, June 2011.

Moncef Krarti **Professor**

EDUCATION	BS, Diplôme d'Ingénieur, Ecole des Ponts et Chaussées, Paris, 1984 MS, Civil Engineering, University of Colorado, 1985 Ph.D., Civil Engineering, University of Colorado, 1987
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2004 – present; Associate Professor, 1998-2004; Assistant Professor, 1991-1998; Associate Chair CEAE 2006-08; Director JCEM program, 1997-1998; Nanyang Technological University, Singapore (sabbatical), 2012-2013 Ecole des Mines de Paris, Adjoint Professor, 1998-Present Texas A&M University, Post-doctoral Fellow, 1986-1988
NON-ACADEMIC EXPERIENCE	Associate, Steven Winter Associates, Norwalk, CT, 1988-1991.
PROFESSIONAL REGISTRATIONS	P.E., Colorado, 1998 to present. LEED-AP, Green Building Certification Institute, 2009 to present.
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Society for Mechanical Engineers (ASME), Fellow. American Society of Heating, Refrigerating, and Air Conditioning (ASHRAE) American Solar Energy Society (ASES)
HONORS AND AWARDS	Distinguished Achievement Award, CEAE Department, 2016. Elected ASME Fellow, 2015. New Inventor Award, University of Colorado at Boulder, 2013. Eckel Award for Excellence, University of Colorado at Boulder, 2012. Service Award, Solar Energy Division Chair, ASME, New York, NY, 2011.
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	American Society for Mechanical Engineers (ASME). Co-director of Integrated and Sustainable Building Equipment and Systems (ISBES). Environmental Division director (2011-13); Editor of ASME Handbook on ISBES, Editor of Monographs. Chair and co-chair of several ASME Energy sustainability conferences, 1992-present. American Society of Heating, Refrigerating, and Air Conditioning (ASHRAE), Voting member of several technical committees on Thermal Energy Storage, Intelligent Buildings, and Building Thermal Load Calculations, 1992-present. of the Civil Engineering Program Criteria Task Committee, 2013. American Solar Energy Society (ASES), Technical Chair of two annual ASES conferences, 2006-present. Editorial Member of Journal of Solar Energy Engineering (JSEE), published by ASME, Chair of Energy Fundamentals Section, 2006-2012. Editorial board of Francis and Taylor publishing on Building Energy Efficient Systems. 2012-present. **University Service** <u>Dept. of Civil, Environmental, & Architectural Engineering (CEAE)</u> Executive Committee. 2010-2013 and 2015-present.

	Graduate Committee. 1998-2002, 2006-2015 Chair of CEAE Faculty Search Committees, 2002-2003, 2006-2007, 2008-2009, 2013-2014. Coordinator of High School Honor Institute: to attract high school honor students to enroll in engineering, 2002-2005. <u>College of Engineering at the University of Colorado - Boulder</u> First Level Review Committee, Chair, Engineering College, 2007-2008. First Level Review Committee, Member, Engineering College, 2004-2008. CU-Campus Carbon Neutral Committee, Member, Campus wide Committee, since 2008.
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	A. Alaidroos and M. Krarti, "Numerical Modeling of Ventilated Wall Cavities with Spray Evaporative Cooling Systems" Energy and Buildings, accepted and available online 24 August (2016) B. Park and M. Krarti, "Energy performance analysis of variable reflectivity envelope systems for commercial buildings" Energy and Buildings, 116, 249-262 (2016). B. Ameer and M. Krarti, "Impact of Subsidization on High Energy Performance Designs for Kuwaiti Residential Buildings, Energy and Buildings, 124, (2016). J. Mun, and M. Krarti, "Optimal Insulation for Ice Rink Floors", Energy and Buildings, In Press, Available online 25 September, (2015). M. Krarti "Evaluation of large scale building energy efficiency retrofit program in Kuwait", Renewable and Sustainable Energy Reviews, 50, 1069-1080, (2015). B. Park, W.V. Srubar, and M. Krarti, "Energy performance analysis of variable thermal resistance envelopes in residential buildings", Energy and Buildings, 103, 317-325, (2015). M. Krarti, Analysis Methods for Building Energy Auditing, Chapter in Energy Efficiency and Renewable Energy Handbook, Second Edition, Y. Goswami and F. Kreith, CRC Press, Taylor and Francis Publishing, (2015). C. Kaltreider, M. Krarti, and J.S. McCartney, "Heat Transfer Analysis of Thermo-Active Foundations". Energy and Buildings, 86, 492-501, (2015). M. Krarti, Thermo-active Foundations for Sustainable Buildings, Editor, monograph, 150 pages, ASME Press, 2015. M. Krarti, Energy Efficient Building Electrical Systems, textbook, 520 pages, Taylor and Francis, 2016.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	DOE Conference on Collaboration between Universities and DOE Research Laboratories, Washington DC, April 1-2, 2015. ASES Workshop, on Energy Efficient Residential Buildings, Phoenix, Aug. 5-6, 2014.

Wil V. Srubar III   Assistant Professor

EDUCATION	BS, Civil Engineering, Texas A&M University, 2006 MS, Civil Engineering, University of Texas Austin, 2008 Ph.D., Civil and Environmental Engineering, Stanford University, 2013
ACADEMIC EXPERIENCE	University of Colorado Boulder: Assistant Professor, 2014-present University of Colorado Boulder: Adjunct Assistant Professor, 2013-2014 Stanford University, Graduate Research Assistant, 2009-2013 University of Texas at Austin, Graduate Teaching Assistant, 2007-2008
NON-ACADEMIC EXPERIENCE	Project Engineer, Alpha Facilities Solutions, San Antonio TX, 1-8, 2009 Graduate Engineer, Walter P. Moore and Associates, Inc, Austin, TX, 6/08 – 1/09 Engineering Intern, Walter P. Moore and Associates, Inc, Austin, TX, 5/06 – 8/06
PROFESSIONAL REGISTRATIONS	Engineer-In-Training (EIT), Texas
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	American Concrete Institute American Society of Civil Engineers (ASCE) Architectural Engineering Institute Structural Engineering Institute American Ceramics Society: Cements Division
HONORS AND AWARDS	Faculty Appreciation Award • University of Colorado 2016 Young Researcher Award • University of Colorado 2016 Excellence in Civil Engineering Education (ExCEEd) Fellow • ASCE 2016 Best Presentation Award • NSF/NIST Polymers and Composites Workshop 2013 ASCE Best Paper Competition • San Jose Branch 2012, 2013 Gerald J. Leiberman Fellowship • Stanford University 2012 Graduate Scholar Award • International Conference on Sustainability 2012 Best Paper Award: Green • American Composites Manufacturers' Association 2011 NSF Graduate Research Fellowship • National Science Foundation 2007
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	*Professional Service* Architectural Engineering Institute • Academic Council June 2015 – present 1st International Conference on Biobased Building Materials • Moderator June 2015 American Society of Engineering Education Conference • Moderator June 2015 ASCE Structures Congress • Session Chair April 2015 Journal of Renewable Materials • Guest Co-Editor 2014-2015 External Peer Reviewer for Grants & Journal Paper August 2013 – present *NSF, NDSEG, EPA, 10+ Scientific and Technical Journals*

	Institutional Service oSTEM Faculty Advisor, College of Engineering and Applied Sciences 2016 – present AEI Student Chapter Faculty Advisor, CEAE Department 2015 – present Graduate Committee Member, CEAE Department 2014 – present
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	a. Hinchcliffe, SA*, KM Hess*, **WV Srubar III**. "Experimental and Theoretical Investigation of Prestressed Natural Fiber-Reinforced Polylactic (PLA) Composite Materials." *Composites Part B: Engineering*, 95: 346-354, 2016. b. Hess, KM*, **WV Srubar III**. "Activating Relaxation-Controlled Diffusion Mechanisms for Tailored Moisture Resistance of Gelatin-based Bioadhesives for Engineered Wood Products." *Composites Part A*, 84: 435-441, 2016. c. Frazier, SD*, **WV Srubar III**. "Evaporation-based Method for Preparing Gelatin Foams with Aligned Tubular Pore Structures." *Materials Science and Engineering C*, 62:467-473, 2016. doi:10.1016/j.msec.2016.01.074 d. Barnhouse, PW*, **WV Srubar III.** "Material Characterization and Hydraulic Conductivity Modeling of Macroporous Recycled-Aggregate Pervious Concrete." *Construction and Building Materials*, 110: 89-97, 2016. e. **Srubar III, WV**, SL Billington. "A Micromechanical Model for Moisture-Induced Deterioration in Fully Biorenewable Wood-Plastic Composites." *Composites Part A: Applied Science and Manufacturing*; 50: 81-92, 2013. doi:10.1016/j.compositesa.2013.02.001 f. **Srubar III, WV**, "An Analytical Model for Predicting the Freeze-Thaw Durability of Natural Fiber Composites." *Composites Part B: Engineering*; 69: 435-442. g. Billington, SL, **WV Srubar III**, AT Michel. "Renewable Biobased Composites for Civil Engineering Applications." in *Sustainable Composites: Fibers, Resins, and Applications*. Netravali, A, C Pastore, Eds. DESTech: Lancaster, PA, pp. 313-336, 2014
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	1. American Concrete Institute (ACI) Conference Fall 2014, 2015, 2016 2. Architectural Engineering Institute (AEI) Conference 2015, 2016 3. Structural Engineering Institute (SEI) Conference 2015 4. American Society of Engineering Education Conference 2015 5. American Ceramics Society: Cements Division Conference 2015, 2016 6. Symposium for Sustainable Infrastructure 2016 7. International Concrete Sustainability Conference 2016 8. 3rd International Conference on Urban Disaster Reduction 2014 9. Sustainable Structures Symposium 2014 10. NSF Durability of Polymers and Polymer Composites Workshop 2013 11. BioEnvironmental Polymer Society Annual Meeting 2012

Sandra L. Vasconez Senior Instructor

EDUCATION	BA, Modern Foreign Languages, The King's College, 1993 MS, Lighting, Rensselaer Polytechnic Institute, 2000 MA, Art History and Museum Studies, University of Denver, 2005
ACADEMIC EXPERIENCE	University of Colorado at Boulder: Senior Instructor, 2007-present; Co-Director and Instructor of Rocky Mountain Lighting Academy 2012-present; Co-Administrator and Instructor of ENVD Lighting Design Certificate, 2014-present Rensselaer Polytechnic Institute, Troy, NY, Adjunct Assistant Professor 1998-2002; Outreach Education Instructor, 1998-2002
NON-ACADEMIC EXPERIENCE	Quenroe Associates, Boulder, CO, Project Manager and Assistant Designer, 2004-2007 Denver Art Museum, Denver, CO, Museum Internship, 2004 Victoria H. Myhren Gallery, University of Denver, CO, Senior Gallery Assistant, 2003-2004 Quenroe Associates, Boulder, CO, Exhibition Design Internship, 2003 Lighting Research Center, Rensselaer Polytechnic Institute, Troy, NY, Manager of Program Development, 1998-2002 MCI Customer Delivery Services, Colorado Springs, CO, Systems Security Administrator, 1994-1995 MCI Citicorp Account, New York, NY, Staff Assistant, 1993-1994
PROFESSIONAL REGISTRATIONS	National Council on Qualification for Lighting Professionals (NCQLP), Lighting Certified, 2002-present
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	IESNA (Illuminating Engineering Society of North America), 1998–present IALD (International Association of Lighting Designers), 2015 – present
HONORS AND AWARDS	Marinus Smith Award, 2013, University of Colorado-Boulder Architectural Engineering Faculty Appreciation Award, Civil, Environmental and Architectural Engineering, 2013 Service Award; Civil, Environmental and Architectural Engineering, 2012
INSTITUTIONAL AND PROFESSIONAL SERVICE IN LAST FIVE YEARS	IES Research Symposium Committee - 2016 **University Service** Dept. of Civil, Environmental & Architectural Engineering (CEAE) Operations Committee, 2015-2016 Chair, David L. DiLaura Faculty Fellowship in Architectural Engineering, 2013-Present Interim Curriculum Committee Chair 2013-2014 Environmental Engineering Search Committee, 2013 Civil, Environmental and Architectural Engineering Cooperative Representative, 2011-2013 Curriculum Committee 2010-12 IES Student Chapter Advisor, 2007-present College of Engineering at the University of Colorado - Boulder

	Undergraduate Education Council, 2013-2014
PRINCIPAL PUBLICATIONS OF LAST FIVE YEARS	Not Applicable
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	Lightfair International Annual Conference – 2012-present International Association of Lighting Designers Annual Conference – 2015, 2016 IES Light + Behavior Symposium – 2014 Rocky Mountain Lighting Academy – 2012-present

Zhiqiang (John) Zhai **Professor**

EDUCATION	• BS, Engineering Mechanics, Tsinghua University, 1994 • MS, Fluid Mechanics, Tsinghua University, 1995 • PhD, Fluid Mechanics, Tsinghua University, 1999 • PhD, Building Technology, MIT, 2003
ACADEMIC EXPERIENCE	University of Colorado Boulder: Professor, 2015-present; Associate Professor, 2010-2015; Assistant Professor, 2003-2010; Faculty Director AREN Program, 2014-2016
NON-ACADEMIC EXPERIENCE	Senior Fellow, Rocky Mountain Institute, Boulder, CO (sabbatical), 2010-2011
PROFESSIONAL REGISTRATIONS	
SCIENTIFIC AND PROFESSIONAL SOCIETIES OF WHICH A MEMBER	• International Society of Indoor Air Quality and Climate (ISIAQ) • International Building Performance Simulation Association (IBPSA) • American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) • China Green Building Council (CGBC)
HONORS AND AWARDS	• Named as Distinguished Lecturer by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 2014. • Invited Participant for 2010 US Frontiers of Engineering (US FOE) Symposium and Invited Organizer for 2011 US FOE Symposium by National Academy of Engineering of US • Research Development Award, Department of Civil, Environmental, and Architectural Engineering, University of Colorado at Boulder, May, 2010 • Distinguished Service Award (DSA) of American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), May, 2010 • William Mong Visiting Research Fellowship in Engineering, The University of Hong Kong, 2009 • 2008 Best Paper Award, International Journal of Building Simulation, 2009 • Sustainability Award of Green Faculty, University of Colorado at Boulder, 2008 • Young Researcher Award, Department of Civil, Environmental, and Architectural Engineering, University of Colorado at Boulder, 2007 • Presidential Fellowship, Massachusetts Institute of Technology, 1999–2003 • Grant-in-Aid Fellowship, American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), 2001 • Martin Family Society of Fellows for Sustainability, Massachusetts Institute of Technology, 2000
INSTITUTIONAL AND PROFESSIONAL	• Associate Editor for Energy and Buildings Journal

SERVICE IN LAST FIVE YEARS	• Editorial Board Member for Building Simulation: An International Journal ; Journal of Building Physics; Indoor and Built Environment Journal; Journal of Energy; Journal AIMS Energy • Voting member and ASHRAE Learning Institute Coordinator of ASHRAE Technical Committee 4.10 – Indoor Environmental Modeling, 2004-Present • Scientific Committee Member for Urban Transitions Global Summit 2016, Sept 5-9, 2016, Shanghai, China • Vice President for the Healthy Buildings 2015 North America Conference, July 19-22, 2015, Boulder, Colorado • Vice President for the 9th International Symposium on Heating, Ventilation and Air Conditioning and the 3rd International Conference on Building Energy and Environment (ISHVAC-COBEE 2015), July 12-15, 2015, Tianjin, China • International Scientific Committee Member for Indoor Air 2016, July 3-8, 2016, Ghent, Belgium • Scientific Committee Member for International Building Physics Conference 2015 (IBPC 2015), June 14-17, 2015, Torino, Italy
PRINCIPAL PUBLICATIONS AND PRESENTATIONS OF LAST FIVE YEARS	• Zhai Z, Yates AP, Duanmu Lin, Wang Z. 2015. An Evaluation and Model of the Chinese Kang System to Improve Domestic Comfort in Northeast Rural China – Part-1: Model Development. Renewable Energy, 84: 3-11. • Zhai Z, Yates AP, Duanmu Lin, Wang Z. 2015. An Evaluation and Model of the Chinese Kang System to Improve Domestic Comfort in Northeast Rural China – Part-2: Result Analysis. Renewable Energy, 84: 12-21. • Zhai Z, Abarr M, AL-Saadi S, and Yate P. 2014. Energy Storage for Residential Buildings. Journal of Architectural Engineering, 20(4). SPECIAL SECTION: Housing and Residential Building Construction, B4014004. • Zhai Z, Xue Yu and Chen Q. 2014. Inverse Design Methods for Indoor Ventilation Systems Using CFD-Based Multi-Objective Genetic Algorithm. Building Simulation: An International Journal, 7(6): 661-669. • Zhai Z and Osborne A. 2013. Simulation-Based Feasibility Study of Improved Air Conditioning Systems for Hospital Operating Room. Frontiers of Architectural Research, 2(4): 468-475. • Zhai Z, Hermansen KA and Al-Saadi S. 2012. The Development of Simplified Rack Boundary Conditions for Numerical Data Center Models. ASHRAE Transactions, 118(2): 436-449.
PROFESSIONAL DEVELOPMENT ACTIVITIES IN THE LAST FIVE YEARS	NSF STEM Mentor Workshop, every Feb, Washington, DC.

Appendix C – Equipment

The major pieces of equipment used by the civil engineering program in courses to support instruction are summarized in the tables below.

Equipment Used in Required Courses for All CVEN Students:

Course	Major Equipment Used
CVEN 2012 Geomatics	Total Stations (6) Leica Electronic theodolites (8) Levels (8), inc. Leica, K&E, Wild types GPS units (2 Leica GS14 antennas and 1 Leica CS20 controller) Tapes (6 fiberglass, 4 metal; 100' and 200') Stadia Rods (7) Range poles/reflector poles (3) Adjustable tripods (10 Wild type, 4 Kern type) Corner prism EDM reflectors (8) Metal detector (1) Misc. flagging and marking equipment
CVEN 3313 Fluids	Hydrostatic force on plane surface apparatus Vertical tank with orifice apparatus Venturi, orifice flow meter, manometer Jet apparatus with target and weights
CVEN 3323 Hydraulics	rod, tape measure, waders, flow meters Armfield hydraulics bench with energy losses apparatus, bicycle pump Armfield hydraulics bench with weir module, hook and point gauge Armfield multi-purpose teaching flume, broad-crested weir
CVEN 3708 Geotechnical Engineering 1	Triaxial cells and consolidometers Proctor and modified Proctor test equipment Atterberg limit apparatus Constant head and falling head permeability setup Mechanical sieve shaker, sieve stacks, and hydrometers
CVEN 3161 Mechanics of Materials	Three MTS universal testing machines for tension and compression testing of structural and geological materials, with capacities of 22 kN, 500 kN, and 4.5 MN. Tinus Olsen Torsional Testing Machine with 2000 in-lb capacity Concrete mixer, scale Whitemann displacement gage, dial gages, strain gages, LVDTs

Equipment used in Proficiency or CEAE Technical Elective Courses for CVEN Students

Course	Major Equipment Used
CVEN 3718 Geotech 2 (proficiency)	Direct shear test machine with shear box, weights, displacement gauges Triaxial test cells with load cells, pressure gauges, LVDT, computer Instructional Centrifuge and demonstration models, data acquisition system
CVEN 3424 W/WW Tmt (proficiency)	Phipps & Bird jar test apparatus Turbidimeter
CVEN 4161 Mechanics of Materials 2 (CEAE Technical Elective)	Instron machine in ITLL and ABAQUS software Torsion Instron machine in ITLL Module with a large frame, a beam-column, restraint beam, counterweight, load arm, load tray and several rulers along the inside of the frame
CVEN 4414 Water Chemistry Lab (CEAE Technical Elective)	Electronic balance, high range (Ohaus model Navigator NOB110) - 1 Electronic balance, low range (Ohaus model Navigator NO2120) – 1 Inductively coupled plasma-atmoic emission spectrophotometer (Vairan model Liberty Series II Axial) – 1 Visible spectrophotometers (Spectronic model 20D+) – 4 Coagulation Jar Testers (Phipps & Bird model Standard) - 4 pH meters (Thermo-Orion model 250Aplus) – 4 pH electrodes (Thermo-Irion triode combination) – 4 Colorimetric Test Kits (Hach model DR/890) - 4 Conductivity meters (Thermo-Orion model 115Aplus) - 4 Drying oven (Fisher model Isotemp 506G) – 1 Muffle furnace (Fisher model Iostemp programmable) – 1 Microscopes (Leitz model IN200) – 2 Heated stir plates (Corning model PC-420) – 4 Computers (Dell Optiplex GX270) – 5 Data acquisition boards (National Instruments) - 4

Appendix D – Institutional Summary

1. **The Institution**

a. **Name and address of the institution:**
The University of Colorado Boulder
College of Engineering and Applied Science
422 UCB
Boulder, Colorado 80309-0422

b. **Name and title of the chief executive officer of the institution:**
Bruce D. Benson - President of the University of Colorado System
Philip P. DiStefano - Chancellor of the Boulder Campus
Russell L. Moore - Provost and Executive Vice Chancellor for Academic Affairs
Robert D. Braun - Dean of the College of Engineering and Applied Science

c. **Name and title of the person submitting the self-study report:**
Submitted by:
Robert D. Braun, Dean
College of Engineering and Applied Science
University of Colorado Boulder
Boulder, Colorado 80309-0422
(303) 492-7006
Bobby.Braun@Colorado.EDU

Contact for ABET matters:
Ken Anderson, Associate Dean for Education
College of Engineering and Applied Science
University of Colorado Boulder
Boulder, Colorado 80309-0422
(303) 492-2066
Ken.Anderson@Colorado.EDU

d. **Name the organizations by which the institution is now accredited and the dates of the initial and most recent accreditation evaluations:**
The University of Colorado – Boulder's general regional accreditation is from the Higher Learning Commission (HLC) of the North Central Association of Colleges and Schools (NCA). The University of Colorado has been accredited by NCA since 1913. Every 10 years, a team of leading external educators visits the University's campus to evaluate the university's programs, policies, and practices and to provide recommendations for continuous improvement. The most recent review took place in 2009-2010, and on August 16, 2010, the Institutional Actions Council of the Higher Learning Commission voted to continue accreditation for the University of Colorado Boulder. For more information, see: http://www.colorado.edu/accreditation/. The most recent self-study is at: http://www.colorado.edu/accreditation/downloads/CUBoulderSelfStudy2010.pdf.

2. **Type of Control**

The University of Colorado is a state-supported institution, governed by an elected Board of Regents under the Colorado Commission on Higher Education.

3. Educational Unit

a. **Campus Administration**
The Dean of the College of Engineering and Applied Science reports to the Provost and Executive Vice Chancellor for Academic Affairs, who reports to the Chancellor and Chief Executive Officer of the Boulder Campus. The Chancellor and Chief Executive Officer reports to the President of the University of Colorado system. Additional details can be found at: http://chancellor.colorado.edu/chancellors-administrative-organization.

b. **College Administration**
The Chief Executive Officer of the College of Engineering and Applied Science is the Dean, Robert D. Braun. The Associate Dean for Education is Ken Anderson; the Associate Dean for Research is Keith Molenaar; and the Associate Dean for Faculty Advancement is JoAnn Silverstein. The Assistant Dean for Inclusive Excellence is Sarah Miller; the Assistant Dean for Advancement is Ann Bishop Shoup; the Assistant Dean for Communications, Strategy and Planning is Phil Larson; the Assistant Dean for Students is Mary Steiner; The Assistant Dean for Programs and Engagement is Doug Smith; and the Assistant Dean for Administration is Cherie Summers.

4. Academic Support Units

The degree programs in the College are supported by a number of other departments and programs, including Applied Mathematics, Physics, Chemistry and Biochemistry, the Herbst Program of Humanities and the Program for Writing and Rhetoric. In addition, the supporting units also teach these courses to other majors throughout the university. The names and titles of the individuals responsible for these units are as follows:

- Applied Mathematics, Keith Julien, Department Chair
- Physics, John Cumalat, Department Chair
- Chemistry and Biochemistry, Carl A. Koval, Department Chair
- Herbst Program of Humanities for Engineers, Leland Giovannelli, Director
- Program for Writing and Rhetoric, John-Michael Rivera, Director

The courses provided by these academic support units are regularly reviewed by the College of Engineering and Applied Science’s Undergraduate Education Council, which is chaired by the Associate Dean for Education. The Council is composed of the associate chairs (or chairs of curriculum committees) or his/her designee for each program, the undergraduate staff advisors for each department, the Assistant Dean for Inclusive Excellence, the Assistant Dean for Students, the Director of the Herbst Program of Humanities, the Director of Assessment and Accreditation, the Director of International Programs, and the Co-Directors of the Integrated Teaching and Learning Laboratory (ITLL). This group meets regularly throughout the year to coordinate matters of common interest and concern with respect to the College's undergraduate programs.

5. Non-academic Support Units

The programs of the College of Engineering and Applied Science are served by several essential campus-wide support units:

1. University Libraries, overseen by James Williams II, Dean of the CU-Boulder Libraries; Leonard Gemmill Engineering Library, overseen by Emily Fidelman, Operations Manager
2. Information Technology Services (ITS), Larry Levine, Assoc. Vice Chancellor and Chief Information Officer;
3. Career Services, Lisa Severy, Assistant Vice Chancellor of Student Affairs and Director

In addition, there are several mechanisms in place to support student academic success:

4. Broadening Opportunity through Leadership and Diversity (BOLD) Center, overseen by Sarah Miller, Assistant Dean for Inclusive Excellence
5. Student Academic Success Center (SASC) for tutoring and academic excellence support services, Corinna Rohse, Director
6. Supplemental peer-based advising is provided by the college's "Engineering Ambassadors"; overseen by Chris Anderson, Student Services Coordinator and Amanda Parker, Director of Access and Recruiting
7. The Engineering Quadrangle Living & Learning Community is a first-year housing option for engineering and pre-engineering students; college liaison is Vanessa Dunn, Director of Student Engagement and Community Building

6. Credit Unit

One semester credit normally represents one class hour or two laboratory hours per week. The campus operates year-round, with fall and spring semesters of 16 weeks each, a 10-week summer session, a three-week "Maymester" academic period between spring semester and summer session, and a three-week "Augmester" academic period between summer session and fall semester. All programs require 128 semester hours to graduate.

7. Tables

.

Table D-1. Program Enrollment and Degree Data

Civil Engineering

	Academic Year		Enrollment Year					Total Undergrad	Total Grad	Degrees Awarded			
			1st	2nd	3rd	4th	5th			Associates	Bachelors	Masters	Doctorates
Current Year	Fall 2016	FT	33	53	62	67	28	243	192	N/A	70	62	31
		PT	1	2	1	4	8	16	37				
1	Fall 2015	FT	55	47	50	70	38	260	196	N/A	58	70	19
		PT	1	0	0	0	8	9	32				
2	Fall 2014	FT	47	48	52	61	45	253	211	N/A	84	66	26
		PT	1	0	2	2	3	8	32				
3	Fall 2013	FT	41	49	53	89	43	275	203	N/A	89	97	10
		PT	0	1	0	5	13	19	42				
4	Fall 2012	FT	31	42	79	88	52	292	233	N/A	76	96	18
		PT	1	1	0	0	5	7	51				

Give official fall term enrollment figures (head count) for the current and preceding four academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the on-site visit.

FT--full time
PT--part time

Table D-2. Personnel

Department of Civil, Environmental, & Architectural Engineering (CEAE)

Civil Engineering Degree

Year[1]: Fall 2016

	HEAD COUNT		FTE[2]
	FT	PT	
Administrative[2]		4	1
Faculty (tenure-track)[3]	43		21
Other Faculty (excluding student Assistants)	7		3
Student Teaching Assistants[4]	28		12
Technicians/Specialists	2	1	1.5
Office/Clerical Employees	12	1	4
Others[5]			

The Head Count data represent the CEAE Department as a whole. These were multiplied by the percentage of time devoted specifically to civil engineering (as opposed to architectural or environmental engineering), resulting in the values shown in the FTE column. For faculty, the percentages listed in Table 6-2 were used. Student Teaching Assistants are based on serving as TAs for courses required for CVEN students (or split if the course is also required for architectural and/or environmental engineering). Staff helping equally with all three programs were split equally, and allocated 33% to CVEN.

APPENDIX E – Rubrics Used for Direct Assessment

The following rubrics are included, which are used for direct assessment of the outcomes shown:

2[b] Design and conduct experiments
- CVEN 3323 Hydraulics
- CVEN 3161 Mechanics of Materials

4[c] Design
- CVEN 4899 Senior Design Project

5[d] Teamwork
- CVEN 4899 Senior Design Project

7[f] Professional and Ethical Issues
- CVEN 4897 Professional Issues in Civil Engineering

8[g] Communication via writing and drawings
- CVEN 4899 Senior Design Project

9[g] Oral Communication
- CVEN 4899 Senior Design Project

10[h] Impact of engineering on society
- CVEN1317 Introduction to Civil Engineering

11[i] Lifelong learning
- CVEN 4897 Professional Issues

12[j] Contemporary issues
- CVEN 4897 Professional Issues
- CVEN1317 Introduction to Civil Engineering

14 Management, business, public policy, and leadership
- CVEN 4899 Senior Design Quiz

CVEN 3323 Hydraulics Lab Report Rubric

Category	High	Medium	Low
Raw Data (10%)	10 – complete, accurate, appropriate precision 9 – complete, accurate, some incorrect precision	5 – 8 – missing some data, some inaccuracies, frequent incorrect precision	0 – 4 – missing data or serious inaccuracies
Sample Calculations (15%)	15 – sample calculations provided for all calculations, complete – using equation in symbols, equation with numerical values and units, final answer that matches table 12 – 14 missing a few sample calculations or steps	6 – 11 missing multiple calculations, missing steps in multiple calculations	0 – 5 missing most or all of the sample calculation, showing only equation and not calculations
Results (35%)	35 – all results are accurate and reported to appropriate number of significant figure 30-34 – most results are accurate and reported to appropriate number of significant figure	11-29 some results are missing, many results are inaccurate or reported to inappropriate number of significant figures, errors can be identified from sample calculations	0 – 10 – most results are inaccurate, or missing, sample calculations are not provided so errors cannot be identified
Answers to Questions (30%)	30 – all questions are answered correctly, all plots are prepared following standard plotting conventions (see attached) 25-29 – answers to questions are mostly correct, plots are mostly correct and mostly follow standard conventions	11-24 – some questions are answered correctly, plots are not necessarily accurate nor follow conventions	0-10 – questions are not answered, are not answered correctly, plots are not accurate, and plots are not made following standard conventions
Professionalism (10%)	9-10 – report follows stated format, spelling is accurate, presentation is clear	3-8 – some issues with report format, some spelling errors	0-2 – report does not follow format, lots of spelling errors

CVEN 3323 Hydraulic Engineering
Lab 4: Weirs

Introduction

A weir is an obstruction in an open channel that is used to measure flow rate. The flow rate can be determined from a single measurement of the weir head, which is the height of the upstream undisturbed water surface above the crest of the weir. The relationship between this weir head and the flow rate depends on the geometry of the channel and on a calibrated discharge coefficient, C_d, that accounts for friction losses.

Objective

The objective of this lab is to determine the discharge coefficient for two sharp-crested weirs – a rectangular weir and a V-notch weir.

Theory

The energy balance between a point upstream of a weir and a point directly over a weir (see Figure 1) is described by the Bernoulli equation, given by

$$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{\gamma} + z_2 + \frac{V_2^2}{2g}, \qquad (1)$$

where p is pressure, γ is specific weight of the fluid, z is elevation, V is average velocity, g is the gravitational constant, and the subscripts 1 and 2 refer to a point upstream of the weir and a point directly over the weir, respectively. Since both Points 1 and 2 are at free surfaces, p_1=p_2=0. Relative to the datum, the elevations of each point are z_1=H_s and z_2=H_s –h. Finally, assuming the upstream velocity head is small relative to the elevation head, $V_1^2/2g \approx 0$. Making these substitutions in (1) and rearranging for V_2 produces

$$v_2 = \sqrt{2gh}, \qquad (2)$$

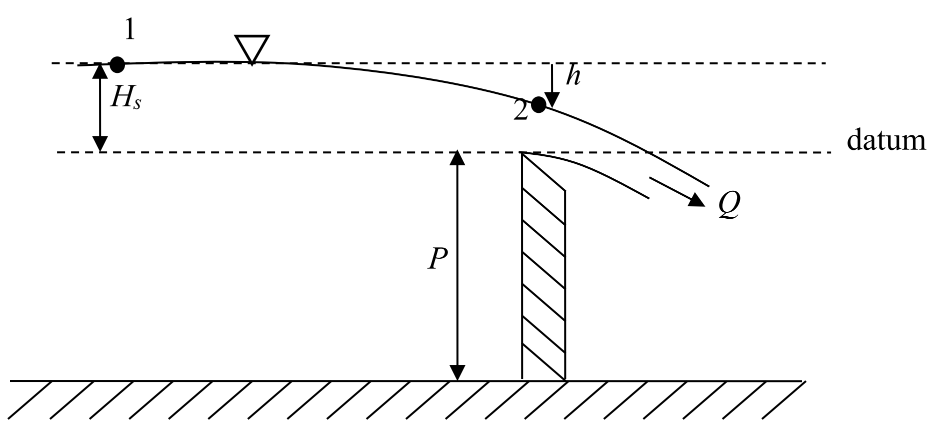


Figure 1. Schematic of flow over a sharp-crested weir.

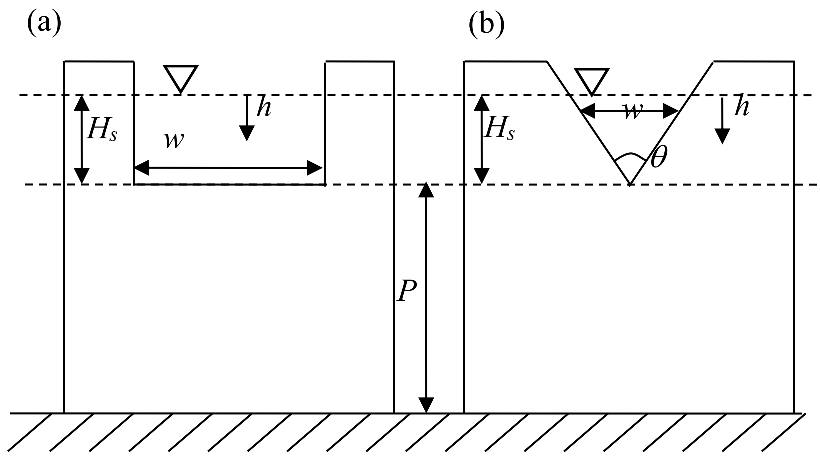


Figure 2. Weir geometry for (a) rectangular weir and (b) V-notch weir.

where v_2 represents the velocity at a distance *h* below the height of water upstream of the weir. The total flow rate, *Q*, over the weir is obtained by integrating $v_2 dA$ over the weir opening, where *dA* is the differential area that depends on *h* and on the weir geometry. The weir geometry for two types of weirs is shown in Figure 2.

For a rectangular weir (Figure 2a), the weir width, *w*, is constant, so *dA*=*w dh*, and the theoretical flow rate, Q_{theor}, is given by

$$Q_{theor} = \int_0^{H_s} v_2 w\, dh = \int_0^{H_s} w\sqrt{2g}\, h^{1/2} dh = \frac{2}{3} w\sqrt{2g}\, H_s^{3/2}. \tag{3}$$

The actual flow rate will be less than the theoretical flow rate because of friction losses that have not been included in (1). The actual flow rate, Q_{actual}, is given by

$$Q_{actual} = C_d Q_{theor} = C_d \frac{2}{3} w\sqrt{2g}\, H_s^{3/2}, \tag{4}$$

where C_d is the discharge coefficient that accounts for energy losses.

For the V-notch weir (Figure 2b), the weir width, *w*, depends on *h*, through the relationship

$$w = 2\left(H_s - h\right)\tan\left(\frac{\theta}{2}\right). \tag{5}$$

The theoretical flow rate for the V-notch weir is given by

$$Q_{theor} = \int_0^{H_s} v_2 w\, dh = \int_0^{H_s} 2(H_s - h)\tan\left(\frac{\theta}{2}\right)\sqrt{2g}\, h^{1/2} dh = 2\sqrt{2g}\tan\left(\frac{\theta}{2}\right)\int_0^{H_s} (H_s h^{1/2} - h^{3/2})\, dh$$
$$= 2\sqrt{2g}\tan\left(\frac{\theta}{2}\right)\left(\frac{2}{3}H_s^{5/2} - \frac{2}{5}H_s^{5/2}\right) = \frac{8}{15}\sqrt{2g}\tan\left(\frac{\theta}{2}\right)H_s^{5/2}. \tag{6}$$

Again, the actual flow rate will be less than the theoretical flow rate because of friction losses that have not been included in (1). The actual flow rate, Q_{actual}, is given by

$$Q_{actual} = C_d Q_{theor} = C_d \frac{8}{15}\sqrt{2g}\tan\left(\frac{\theta}{2}\right)H_s^{5/2},$$

(7)

where C_d is the discharge coefficient that accounts for energy losses.

Equipment

- Armfield Hydraulics Bench with weir module
- Hook and point gauge
- Graduated cylinder
- Stopwatch

Procedure

1. Secure the rectangular weir (w = 2 in) to the end of the flow channel with the thumb nuts, and attach the hook and point gauge over the channel.
2. Zero the Vernier scale as follows:
    a. Screw the fine adjustment nut at the top of the mast so that half of the threads are above the nut and half of the threads are below the nut.
    b. Set the Vernier gauge to a datum with the point on the bottom of the weir. Slide the point in the mast until the point rests at the top of the weir crest.
    c. Lock the locking screw at the top of the mast to keep the point at that level.
    d. Slide the Vernier scale on the mast to line up the zeroes of both the Vernier scale and the mast scale. Now the point can be moved up using the mast and the fine adjustment nut.
3. Open the flow valve slightly and turn on the pump. Adjust the flow to the highest flow rate possible without overflowing the channel. Allow the flow to stabilize.
4. Use the mast and fine adjustment nut to move the point to the surface of the water so that it is just touching the water surface. Record the height of water above the notch. Record the measurement error in the height of water.
5. Using the graduated cylinder and stop watch, collect a volume of water over a specified time to determine the flow rate. Record the measurement error in the volume and time.
6. Adjust the flow control know to decrease the head and flow rate, and repeat Steps 4 and 5. Continue to decrease the flow rate and make measurements until you have made measurements for five different flow rates.
7. Repeat Steps 1-6 for the V-notch weir (θ=90°).
8. Turn off pump.

Results

Fill in Results Tables 1 and 2 (available in Excel spreadsheet format on the Desire2Learn).

Questions

1. For the rectangular weir, plot the measured flow rate, Q_{actual}, vs. $H_s^{3/2}$. Include the horizontal and vertical error bars. Fit a linear trendline with a zero intercept through the data, and show the equation of the trendline on the plot. From the slope and (4), calculate the discharge coefficient, C_d. Based on your data and your measurement error, can the discharge coefficient be considered constant, or do your data (included error measurements) indicate that it varies with the flow conditions (i.e., do you see more variation than would be expected from typical measurement error)?

2. For the V-notch weir, plot the measured flow rate, Q_{actual}, vs. $H_s^{5/2}$. Include horizontal and vertical error bars. Fit a linear trendline with a zero intercept through the data, and show the equation of the trendline on the plot. From this slope and (7), calculate the discharge coefficient, C_d. Note that the angle of the V-notch weir is given in degrees, but the trig functions in Excel require the angle to be in radians. Based on your data and your measurement error, can the discharge coefficient be considered constant, or do your data (included error measurements) indicate that it varies with the flow conditions (i.e., do you see more variation than would be expected from typical measurement error)?

CVEN 3161 Mechanics of Materials – Rubric for Design and Conduct Experiments

	Below adequate	Adequate	Superior
Percentage of total points earned on lab write-up, per guidelines below:	<80%	80-90%	≥90%

1. GENERAL FORMAT (10%)

Format

- The entire report should be stapled or bound and NOT be placed in a folder or cover.
- Text should be 1.0 line spaced and may be done in 11 point or 12 point font.

Figures, Tables, Graphs, and Sections

Figures, Tables and Graphs should each have a title and a number (graph titles are to be label BELOW the graph and table titles are to be label ABOVE the table). Graphs should have white background so data points and trendlines are easy to see. Graphs should have the axes labeled, the scale indicated, and should be of appropriate size for the reader to see the results. It is sometimes necessary to give a graph or table its own page. If placed within the text, tables and graphs should be separated from the text with appropriate borders. These graphs and tables should be referenced in the text. The report should be divided into the sections discussed below. These sections should appear in the order presented.

2. TITLE PAGE

- Report Title.
- Entity presented by (you).
- Group Number/Name.
- Organization that the report was done for (University, Department & Course #).
- Date the Experiment was completed.
- Date report was submitted.

3. ABSTRACT (5%)

- The abstract is a brief description of what is contained in the report. It should cover the main purpose of the experiment, a general description of what was done, a general description of the equipments used, a broad overview of the results that were obtained, and conclusions as to whether the results seem reasonable. The abstract should be able to stand alone from the rest of the report. It should not directly refer to figures or tables or other content of the rest of the report.

4. TABLE OF CONTENTS, LIST OF FIGURES, LIST OF TABLES (5%)

- The Table of Contents should list all the sections and what page they start on.
- List of figures and list of tables should contain all figures and tables including name and number listed in the text and the page they start on.

5. INTRODUCTION (10%)

- Discuss the background necessary to understand the report. This would include brief description of theory, definitions of major terms, objective(s) and purpose of the lab, and any assumptions used during experiment.
- Discuss the properties that are extrapolated or calculated from the test.
- Short description of how the stress-strain graph was created and how the data was obtained.
- Appropriate background so that a common reader can understand the experiment.
- Brief description of the materials used.

6. SPECIMEN PREPARATION (10%)

- Create a list of steps as to how the concrete cylinders were prepared, including the concrete mix design for your group.

7. EXPERIMENTAL PROCEDURE (10%)

- Create a list of steps as to how the experiment was conducted. Include a listing of equipment used, sketches or drawings of the test specimen(s) including dimensions and the testing setup.

8. TEST RESULTS (20%)

Your results should make use of charts and tables, and explain your figures including measured quantities, graphs or charts created for understanding the results, and any properties calculated, such as the cross sectional area (Ao) and the original gauge length of the specimen (Lo, i.e. the height of cylinder).

A minimum of the following should be included:

- Plot of test data force vs. displacement (original data).
- Plot of test data in positive force vs. positive displacement.
- Plot of Stress vs. Strain. The curve should start at (0,0), in other words at zero stain and zero stress.
- "Fix" your data by adding or subtracting to every value the same amount, which represents the deformation of the samples before they are in full contact with the loading heads.

For the compression test, calculate and show the following properties obtained from each specimen and the average values:

- E (Modulus of Elasticity)
- f_c' (Max. stress = the compressive strength of concrete)
- ε_c (The strain corresponding to f_c')

For the splitting tension test, calculate and show the following property obtained from the specimen:

- ft (the tensile strength of concrete measured by the splitting tension test)

Numerical results are best presented in table form. It should be noted which properties were calculated, and which were extrapolated graphically.

9. ANALYSIS AND CONCLUSION (20%)

- Explain the failure mechanisms of concrete under compression and tension
- Explain the fracture surfaces of concrete under compression and splitting tension
- Explain the effect of end constraint on compressive strength of concrete.
- Identify any large errors and attempt to provide explanations of possible causes.
- Include observations from lab.

10. REFERENCES (5%)

Whenever you use a source within the body of the paper, this source should be referenced.

11. APPENDICES (5%)

- Test data: Include the data received from the tests. You are recommended to use Excel Spreadsheets and to show both the originally measured data and the data that you calculated and/or changed. If the raw data is lengthy, you may include only a sampling of it.
- Sample Calculations: Include all sample calculations in this section for any equations that you used in writing the report.

ABET Student Learning Outcome: 4[c] Design
CVEN 4899 Senior Capstone Design Rubric

CU CEAE Outcome	ABET outcome	Sub-topics	Poor	Needs Improvement	Adequate	Superior	Weight
			1	2	3	4	
4	c	Ability to state the problem and constraints	Client needs not assessed; problem poorly defined; key constraints lacking	Client needs not thoroughly assessed; problem not well defined; 1 or more constraints not addressed	Client needs thoroughly assessed, problem well-defined, all critical constraints addressed	Client needs thoroughly assessed, problem well-defined; all constraints stated; unexpected insight into client need	5%
		Ability to compare and make selection between design alternatives	Only 1 valid alternative evaluated; no decision or decision not justified	2 or more distinct designs that are valid; decision is objective and justified	3 or more distinct design alternatives that are valid; decision process clear with weighted criteria and alternative scores	3 or more distinct design alternatives that are valid, at least 1 valid design is innovative; decision process clear with weighted criteria and alternative scoring	5%
		Multiple constraints and criteria appropriate to the design were considered	No explicit evaluation of alternatives in a quantitative fashion	Alternatives compared based on multiple criteria but weighting of importance of criteria unclear; scores unclear	Alternatives are compared using multiple criteria than encompass economic, environmental, social, political, ethical, health and safety, and sustainability; criteria weighted and scored based on clear justification	Alternatives are compared using multiple criteria than encompass economic, environmental, social, political, ethical, health and safety, and sustainability; criteria weighted and scored based on clear justification	5%
		Ability to correctly complete a design	Detailed design is not present or is severely flawed and/or required significant amounts of help;	Design is somewhat flawed and/or required significant amounts of help; was unable to follow a previous example competently	Can design with only minor possible issues with minimal outside help; can follow a previous example competently	Can correctly design on their own based on fundamentals and/or design guidance documents without outside assistance	50%

ABET Student Learning Outcome: 5[d] Teamwork
CVEN 4899 Senior Capstone Design
Rubric

Sub-topics	Poor **1**	Needs Improvement **2**	Adequate **3**	Superior **4**	Weight
Attendance; Contribution	Absent from team meetings or work sessions >50% of the time; peer evaluations indicate contributed <50% of fair share'	Frequently absent from team meetings; sometimes depends on others to complete their work; contributes less than fair share of the project workload	Only rarely absent from team meetings but does not inconvenience group; contributes a fair share of the project workload	Present at all team meetings; contributes periodically to leading the team; contributes more than required	50%
Support	Is competitive and/or individualistic rather than cooperative and supportive	Respects other team members		Treats all team member with respect; listen to ideas; acknowledges the work of others; help others	50%

Note: In spring 2017 the instructor simplified the peer rating process to a single score, described to the students as follows: Please rate the effort, participation, and contribution level of each team member in your team. This rating should NOT be based on professors' grades for deliverables, but based on your experience with this team member. Use a scale of 1 to 5.

ABET Student Learning Outcome: Ethics and Professional Issues
CVEN 4897 Professional Issues in Civil Engineering, Fall 2016
ASSIGNMENT 4: Case Study Ethics & Contemporary Issues

Rubric

Total points earned of 80 max (technical elements)	Poor	Needs Improvement	Adequate	Superior
	55.9 or less	56 to 63.9 pts	64 to 71.9 pts	72 or more
	Lacking a strong understanding of micro- and macro- ethical issues relevant to civil engineering	Needs to improve ability to apply micro and or macro ethical understanding to civil engineering issues	Demonstrates sufficient knowledge of micro- and macro- ethical issues relevant to civil engineering	Demonstrates strong understanding of engineering codes of ethics, microethics, macroethics; can apply this understanding in a situation relevant to civil engineering

1. Using the ASCE or NSPE Code of Ethics, discuss two examples of unethical behavior that appears to have occurred in the events that led to the flooding of New Orleans during Hurricane Katrina, the investigation of the situation, or the aftermath. Cite the specific part of the Code by number, paraphrase it, and discuss the elements that relate to the project that seem to violate this provision in the code. Cite references to support your discussion. These issues are examples of microethics. Length of discussion should total more than a half a page (a full page is more likely needed for a complete discussion). [14 pts]

   6 pts per example: Example itself 2 pts,
   Code portion selected 2 pts (number 0.5 pts, paraphrase 1.5 pts)
   Discussion describing why event seems to violate this part of code; quality, logical, etc. +2 pts; Overall length half page or more in correct format (single spaced, times new roman 12) +2 pts (scale down when too short)

2. Select two different foundational ethical theories (examples include: utilitarianism, care ethics, virtue ethics, duty ethics, rights ethics, etc.). Compare and contrast how one would act differently in this case (either prior to Katrina disaster, during disaster, or during the rebuild after disaster) if their actions were driven by the two different theories. Use one specific example. Length of discussion should total 0.5 pages or more. [14 pts]

   Foundational ethical theory 3 pts each x 2 = 6 pts
   "scenario" described with actions that align with each of the two ethical theories = 3 pts each x 2 theories = 6 pts
   Overall length half page or more in correct format (single spaced, times new roman 12) +2 pts (scale down when too short)

3. Select and discuss one macroethical issue that appears to be relevant to the situation. Describe the macroethical issue and how it relates to the Katrina/New Orleans situation. Length of discussion should total 0.5 pages or more. [12 pts]
   Macroethical issue clearly identified, and actually a macroethical issues +3 pts
   Relates macroethical issue to Katrina/New Orleans, discussion quality +7 pts
   length half page or more in correct format +2 pts (scale down when too short)

4. Select one of the six principles from the Social Justice essay by Riley and Lambrinidou (2015). Discuss how this principle could be applied to the rebuilding of New Orleans after Hurricane Katrina. How might applying this principle change what would happen compared to "business as usual" engineering? Is there any evidence that some of these ideas from this principle were actually applied during the rebuild process? Be sure to include adequate citations. Length of discussion should be a minimum of 0.5 pages. [13 pts]
   Which of 6 principles is clear – 2 pts
   Discussion of relevance in post-Katrina rebuild – 5 pts
   Discuss how application of principle different than typical – 2 pts
   Any evidence this principle was applied – 2 pts
   Length – 2 pts

5. Discuss how the situation with New Orleans relates to the ASCE Infrastructure Report Card. For example, levees were graded as a D- in 2013 (the same in 2009 D-; levees were not graded in the 2001 and 2005 reports). Do you think levees were added to the infrastructure report partly as a result from Katrina? The hurricane also damaged a number of other infrastructure systems in New Orleans. Were any lessons learned about convincing the public to invest in infrastructure? Length of discussion should be a minimum of 0.5 pages. [12 pts]
   Discussion of infrastructure report card grades in general +2 pts
   Discussion of why think levees added to report card +2 pts
   Other infrastructure damaged as part of Katrina +3 pts
   Infrastructure investment and the public +3 pts
   Length sufficiently demonstrates depth of thinking – 2 pts

6. Contemporary issues facing civil engineers include engineering infrastructure in the face of uncertainty, in particular increased uncertainty related to climate change. Discuss how uncertainty was handled in the flood protection system for New Orleans pre-Katrina. Discuss how uncertainty was handled in the post-flood reconstruction. Discuss if the newer approaches seem adequate or not. What other strategies could be used? Length of discussion should be a minimum of 0.5 pages. [15 pts]
   - Uncertainty handled pre-Katrina – 4 pts
   - Uncertainty handled post-Katrina – 4 pts
   - Newer approaches adequate? – 3 pts
   - Other strategies – 2 pts
   - Sufficient Length showing depth of thinking – 2 pts

ABET Student Learning Outcome: 8[g] Communication via Writing/Drawings
CVEN 4899 Senior Capstone Design Rubric

CU CEAE Outcome	ABET outcome	Sub-topics	Poor	Needs Improvement	Adequate	Superior	Weight
			1	**2**	**3**	**4**	
8	**g**	Style	Many errors in grammar, spelling, and/or punctuation; poor appearance of report, figure/tables/references			"Strunk and White" compliant	**10%**
		Organization	Loses reader: no clear structure or pattern; whole report lacks clarity, story lacks coherence overall; lack of/too many paragraph transitions; table/figures do not link to text			Information is presented in a logical, interesting way which is easy to follow; content and organization outlined in the introduction; good use of headers; complete table of contents; extensive use of figures and tables that support the text	**5%**
		Ability to effectively use CAD/Revit and other drawings to communicate design	No use of basic design drawings or CAD/Revit	Some use of basic design drawings; CAD/Revit not used or unclear	Good use of design drawings; adequate use of CAD/Revit to convey design	Extensive use of design drawings; well documents with high quality CAD/Revit	**20%**

ABET Student Learning Outcome: 9[g] Oral Communication
CVEN 4899 Senior Capstone Design Rubric

Sub-topics	Poor **1**	Needs Improvement **2**	Adequate **3**	Superior **4**	Weight
quality of content	does not give audience map of presentation content; not a clear focus and direction of presentation; no transitions; lacks sufficient detail	Seems uncomfortable with information	at ease with content;	well organized, audience knows trajectory of presentation, presentation has appropriate level of detail and technical content for the time constraint and the audience	**50%**
presentation mechanics (body position, eye contact, body movement, oral delivery; personal appearance)	Does not interact with audience; faces screen; not enough eye contact; body movement (completely lacking or distracting); poor English; too fast/slow; too many ums, voice volume too low; lack of enthusiasm	Some interaction with audience; very little eye contact with audience; body movement somewhat distracting; good pace of speech, just a few ums, volume of voice appropriate	Some interaction with audience, generally good eye contact, body movements not distracting, good pace of speech, few to no ums, volume of voice good; some enthusiasm	Interacts with audience throughout presentation; always facing audience; eye contact is excellent (scanning, looking at people), good use of hand gestures and body movement; excellent pace of speech, projects voice, great enthusiasm	**20%**
visual aids	Majority of the slides are unclear or incomprehensible; text too small; too little/too much detail; few figures/ tables	Many slides contain errors or are not clearly visible; fonts often too small; color distracting or hard to read; either completely boring or unnecessary "cute" cartoons; figures and tables not used effectively	Few visual aids have minor errors or are not clearly visible; most have adequate font size; good use of figures and tables	All visual aids are easy to read with adequate font size, good use of color, and extensive use of figures and tables for clarity; appropriate amount of information on slide	**20%**
questions	does not ask for questions; does not answer questions	asks for questions; sometimes misunderstands questions; does not answer questions adequately	asks for questions; listens carefully and understands the questions; answers questions adequately	effectively opens ("I'd be happy to answer questions"); answer questions effectively and smoothly; is able to explain and elaborate on information presented	**10%**

ABET Student Learning Outcome: 10[h] Impact of Engineering on Society
CVEN 1317 Homework 2: Sustainability and Civil Engineering

Rubric

Total points earned of 67 max (technical elements)	Poor	Needs Improvement	Adequate	Superior
	46.8 or less	46.9 to 53.5 pts	53.6 to 60.2 pts	60.3 or more
	Weak understanding of social, economic, and/or environmental impacts of civil engineering projects	Needs to improve understanding of environmental, social, and/or economics impacts from CE projects	Demonstrates understanding of social, environmental, and economic impacts from civil engineering projects	Demonstrates strong understanding of social, environmental, and economic impacts from CE projects

Answer the following questions:

1. [15 pts] Exploring the Envision 2.0 rating system for sustainable infrastructure [http://www.sustainableinfrastructure.org/index.cfm]
Look at the point categories in the Envision 2.0 rating system and compare them against the classic three pillars of sustainability. Identify five of the 55 point categories which fall primarily into each of the pillars. [see pg. 23 of the Guidance Manual for the point categories]. List by number AND name (i.e. 1. QL1.1 Improve community quality of life)
Many of the categories can satisfy more than 1 pillar, but **do not** repeat the categories in multiple pillars.
Briefly describe WHY you classified each point category under each pillar (about 1 sentence per point category). If their explanation convincing of different pillar, OK

Examples shown

Economic	Environmental (most RA, NW, and CR)	Social (basically all QL, many LD)
• RA2.1 reduce energy consumption • LD3.3 extend useful life • RA3.2 reduce potable water consumption • CR2.5 manage heat island effects • NW1.3 preserve prime farmland	• RA1.3 use recycled materials • CR1.1 reduce greenhouse gas emissions • NW1.1 preserve prime habitat • NW3.1 preserve species biodiversity • RA2.2 Use renewable energy	• QL1.1 improve community quality of life • LD1.3 Foster collaboration and teamwork • LD1.4 provide for stakeholder input • CR2.4 prepare for short-term hazards • QL2.4 improve community mobility and access

NEED Five in each pillar, for total of 15 ENVISION categories
+0.5 pts each for an actual category of ENVISION into a logical sustainability pillar [+7.5 total]
+0.5 pts for each SENTENCE describing why [7.5 pts total for justification]
If their explanation convincing of different pillar, OK

2. [10] For the US 97 Lava Butte project – select one of the credit categories from ENVISION that you mapped to primarily **environmental impacts** pillar of sustainability in Q1 above.

i) List the credit by number (ie QL1.1) and name (i.e. Community quality of life). [1 pt]

-0.5 if missing the number OR the name

ii) Discuss what was done on the Lava Butte project that would allow it to earn this credit [3 pts], and describe what level (improved, enhanced, superior…) [1 pt] and number of points (from the scorecard) you think it should receive [1 pt; needs to be the correct number of points for that credit and level they picked; check scorecard to confirm correct] and why [1 pt] [6 pts]

iii) discuss how this element contributes to the overall sustainability of the project, perhaps extending benefits into the economic and/or social realms [3 pts]

Answers will vary. Example:

i) ENVISION RA1.3 recycled materials:

ii) Because the LavaButte project got Greenroads MR-4 recycled materials points it would also earn those ENVISION RA1.3 points. The LavaButte project used an average of ~25% reclaimed asphalt pavement for the project. In ENVISION it could be awarded 2, 5, 11, or 14 points in RA1.3. In the ENVISION user manual it says if 20-50% of the materials used by volume or weight are recycled or reclaimed materials the rating is enhanced and 5 points are awarded. Thus I believe that the LavaButte project should have earned 5 pts.

iii) Using recycled materials contributes primarily to the environmental sustainability of the project by avoiding the use of virgin materials. In the case of asphalt, petroleum is used for "new" asphalt, which is a finite natural resource. The use of the on-site reclaimed asphalt pavement may have also saved money, since the old pavement on-site was turned into the new pavement. Socially it might have been safer to reclaim the on-site pavement since fewer truck trips to bring off-site resources to the site and truck the old pavement off-site as a waste material.

3. [10] For the US 97 Lava Butte project – select one of the credit categories from ENVISION that you mapped primarily to the **social impact** pillar of sustainability in Q1 above.

i) list acronym and name of selected credit [1 pt] -0.5 if missing the number OR the name

ii) discuss what was done on the Lava Butte project that would allow it to earn this credit [3 pts], and describe what level (improved, enhanced, superior…) [1 pt] and number of points (from the scorecard) you think it should receive [1 pt; needs to be the correct number of points for that credit and level they picked; check scorecard to confirm correct] and why [1 pt] [6 pts]

iii) discuss how this element contributes to the overall sustainability of the project, perhaps extending benefits into the economic and/or environmental realms [3 pts]

answers will vary; example:

i) ENVISION QL3.2 preserve views and local character:

ii) Because the LavaButte project got the "scenic views" points in the Greenroads rating system, it would likely get the QL3.2 preserve views ENVISION points. The LavaButte roadway passed through a National Forest and previously had scenic views. The new road maintained those scenic views. The project also earned Greenroads points for site vegetation, which likely contributes to the scenic nature of the project. Therefore, I would guess the project could earn the "superior" rating in ENVISION with 6 points. The ENVISION criteria for superior are "public view plan implemented with little to no deviation. Contract includes clauses on the preservation of high value landscapes… [including] the handling of on-site trees, vegetation, and other features." [ENVISION p. 52]

iii) Discusions will vary, but should attempt to link to other 2 sustainability pillars….

4. [10] For the US 97 Lava Butte project – select one of the credit categories from ENVISION that you mapped primarily to the **economic impact** pillar of sustainability in Q1 above.

i) list acronym and name of selected credit [1 pt]

ii) discuss what was done on the Lava Butte project that would allow it to earn this credit [3 pts], and describe what level (improved, enhanced, superior…) [1 pt] and number of points (from the scorecard) you think it should receive [1 pt] and why [1 pt] [6 pts]

iii) discuss how this element contributes to the overall sustainability of the project, perhaps extending benefits into the social and/or environmental realms [3 pts]

5. The American Society for Civil Engineering (ASCE) has rated many of the nation's infrastructure systems as deficient. http://www.infrastructurereportcard.org/

Report Card for America's Infrastructure. 2013. American Society of Civil Engineers. http://www.infrastructurereportcard.org/a/#p/overview/executive-summary

a) [4 pts] Select one of the topics graded in the report card. Summarize its 2013 ASCE grade, and the main justification for this grade. The length of your discussion should be a half page or more.

Infrastructure areas here; 0.5 pts for selecting one of these, 0.5 pts why, 1 pt correct 2013 grade, 2 pts how it got this grade (-0.5 pts if answer short)

Bridges	C+	Rail	C+	Solid Waste	B-
Aviation	D	Parks	C-	Hazardous waste	D
Dams	D	Energy	D+	Drinking Water	D
Levees	D-	Schools	D	Wastewater	D
Roads	D	Transit	D	Inland Waterways	D-

b) [8 pts] Discuss why it is important that this category of infrastructure consider sustainability. In what ways can development in this area be done sustainably? Be sure to address economic, environmental, and social elements in your discussion. If new design and construction in this infrastructure area are done sustainably, discuss how this could lead to improvements in future report card grades. The length of your answer should be 1 page long or more.

Discussion answers will vary;
2 pts based on length of response; full credit if 1 pg single spaced 12 pt font 1" margins, reduce %wise from there (half page = -1 pts)
2 pts discuss Importance of sustainability
3 pts ideas to be sustainable (1 pt for each pillar: economic, social, environmental)
1 pts discuss how sustainability will help improve future report card grades

5. Make a hierarchical concept map that describes sustainability in the context of engineering and infrastructure. Don't leave out any important concepts.
Try to be as complete as possible; this should take you about 30 to 60 minutes.
Include concepts (nodes) enclosed in a box or oval.
Include linking lines that represent relations between concepts, with arrow heads that indicate the direction of the relationship ***and*** labels that indicate the type of relationship.
Your concept map can be hand-drawn if you take a photo (like with your phone) and paste the photo into your assignment or upload into D2L. Alternatively you can draw your concept map in powerpoint or using a free online tool. [10 pts]

+1 POINT if the map includes 1 or more nodes (concepts) that convey the environmental pillar of sustainability (environment, water, air, natural resources, etc.)
+1 point if the map includes 1 or more nodes (concepts) that map to the **social** pillar (society, health, safety, culture, infrastructure, etc.)
+1 point for maps that include one or more nodes (concepts) that map to the economic pillar (economic, jobs, cost, save money, …)
+1 point for inclusion of ideas that relate to future (long-term, etc.)

Up to 3 POINTS FOR TOTAL NUMBER OF nodes (concepts) +0.15 pt per node
Example: +1.5 pts for 10, +3 pts for 20 or more concepts

Up to 2 points for characteristics of the links (all links should have arrow and label)

+2 points if all links have arrow AND label (label is more important)

Scale down for % of links missing arrows and/or labels

(examples, all links have labels but no arrows = 1.3 pts; if all links have arrows but no labels 0.7 pts; all links have arrows but half are missing labels = 1.4 pts, etc)

Up to 1 Point for hierarchy (maximum number of concepts linked in 1 chain)

+1 pt 5 or more concept chain; +0.9 pts 4 concept chain; +0.7 pts 3 concept chain; +0.5 pts if max of a 2 concept chain

ABET Student Learning Outcome Direct Assessment: 11[i] Lifelong Learning
CVEN 4897 Professional Issues in Civil Engineering, Fall 2016
ASSIGNMENT 3: Professional Licensure [50 pts]

Overall assignment score used to determine student knowledge related to lifelong learning

	Poor	Needs Improvement	Adequate	Superior
Total points earned of 50 max	34.9 or less	35 to 39.9 pts	40 to 44.9 pts	45 or more
		Did not fully demonstrate that they understand all of the skills, knowledge, and attitudes that are desirable at the point of professional licensure must grow after the BS degree; perhaps does not fully understand the steps to become professionally licensed		Displays a recognition for the ability to engage in lifelong learning and need for LLL based on growing skills related to BOK outcomes and understanding path to professional licensure

Material in the ASCE Body of Knowledge for Civil Engineering, 2nd Edition, supports this assignment. Read Chapter 1 and 'Guidance for Students' p. 46-49). Also, focus your attention on the 24 outcomes and the **definitions** for each possible level of achievement (1-6) for these outcomes. These are summarized effectively in Appendix I - Body of Knowledge Outcome Rubric (pg. 103-112).

1. [24 pts] Thinking back on all the courses that you have taken/plan to take as part of your BS degree in CVEN, list the courses that you feel have helped you achieve each of the levels of achievement for each outcome. Fill in the course numbers in the table, where appropriate, as: C1317 = CVEN 1317; A1027=AREN 1027. Include elective courses. A single course can be filled in more than one cell of the table. It is hoped that for each "gray" cell in the table below, you will be able to fill in one **<u>or more</u>** course #s. You may find that you have reached a higher level than the minimum Bachelor's level of achievement based on the courses that you have taken. [Looking that the syllabus for this course, you should find that you can fill in CVEN 4897 for some outcomes.]

Level Outcome	1 Knowledge	2 Comprehension	3 Application	4 Analysis	5 Synthesis	6 Evaluation
Math						
Natural sciences						
Humanities						
Social sciences						
Materials science						
Mechanics						
Experiments						

Problem solving & recognition						
Design						
Sustainability						
Contemp. issues & hist. perspective						
Risk & uncertainty						
Project management						
Breadth in civil engrg						
Technical specialization						
Communication						
Public policy						
Business & public administration						
Globalization						
Leadership						
Teamwork						
Attitudes						
Lifelong learning						
Professional & ethical responsibility						

Full credit for filling in courses into all of the gray highlighted cells below; at least 5 of the outcomes should have more than 1 course for full credit; OK if they say "no courses" (since they truly may not have had a course that maps to the outcome; OK to have courses listed in the white cells of the table
There are 24 outcomes listed (rows of the table), so +1 pt for filling in the courses correctly for each

2. [5 pts] ADD to the table above any co-curricular and/or extracurricular experiences you have had during college (such as ASCE concrete canoe, EWB project team, internship at XX, undergraduate research, etc.) that helped you achieve particular outcomes and specified levels of achievement.
Full credit if at least one co-curricular experience is shown in the table above

It is hoped that you can fill in courses and/or experiences for all of the outcomes and the expected levels of achievement for a Bachelor's degree. Reflect on your results as you consider the Question 3:

3. [4 pts] Complete the table below, ranking:
    a) Five outcomes you believe to be MOST IMPORTANT in your future CVEN career (1= most important, 2 = 2nd most important, etc.)

1 pt for identifying 5 outcomes with the numbers 1 to 5 in column (a) below; if only 4 filled in 0.8 pts, etc

b) Five outcomes you believe will be the LEAST important in your future CVEN career (24=lowest importance; 23= 2nd least important, etc.)

1 pt for filling in #s 20, 21, 22, 23, 24 on 5 of the outcomes in column (b) of the table

c) Three skills/knowledge outcomes that you feel are your Personal weakest (1= weakest)

1 pt for identifying 3 weak skills (ok if use 1, 2, 3 OR so labeled with 1)

d) Three outcomes that you think should receive more attention in the CVEN curriculum at CU

1 pt for identifying 1 "weakest" – can be tallies or rank 1, 2, 3 ok

Civil Engineering BOK Outcome	(a) Most important	(b) Least important	(c) Personal Weakest	(d) More needed in CVEN degree
1. **MATH**.				
2. **NATURAL SCIENCES**.				
3. **HUMANITIES**.				
4. **SOCIAL SCIENCES**.				
5. **MATERIAL SCIENCE**.				
6. **MECHANICS**.				
7. **EXPERIMENTS**.				
8. **PROBLEM RECOGNITION & SOLVING**.				
9. **DESIGN**.				
10. **SUSTAINABILITY**.				
11. **CONTEMPORARY ISSUES & HISTORICAL PERSPECTIVES.**				
12. **RISK and UNCERTAINTY**.				
13. **PROJECT MANAGEMENT**.				
14. **BREADTH** in civil engineering.				
15. **TECHNICAL SPECIALIZATION**.				
16. **COMMUNICATION**.				
17. **PUBLIC POLICY**.				
18. **BUSINESS and PUBLIC ADMINISTRATION**.				
19. **GLOBALIZATION**.				
20. **LEADERSHIP**				
21. **TEAMWORK**.				
22. **ATTITUDES**.				
23. **LIFELONG LEARNING**				
24. **PROFESSIONAL** and **ETHICAL RESPONSIBILITY**.				

4. [5 pts] Read the list out attitudes that the BOK indicates are supportive of the professional practice of civil engineering – these are described on pg. 148 and in Appendix O. Discuss 5 attitudes from among the list that you believe are most important for professional civil engineers and why. Discuss whether or not you embody these attitudes; if not, discuss how you might work to grow these attitudes in yourself. {your answer should be about 250-500 words long}

+0.6 pts each x 5 attitudes: for selecting one of the attitudes from the list (+0.1), stated why important (+0.3), if personally embody the attitude or not and how to grow (+0.2)

The list of attitudes from the BOK2 is: **commitment, confidence, consideration of others, curiosity, entrepreneurship, fairness, high expectations, honesty, integrity, intuition, judgment, optimism, persistence, positiveness, respect, self esteem, sensitivity, thoughtfulness, thoroughness, and tolerance**

2 pts for correct overall length of response (250-500 words)

>60% too short	40-60% too short words	20-40% too short	10-20% too short	0-10% too short	Within rec word limits	10-20% too long	20-50% too long	>50% too long
0 pts	+0.5 pt	+0.7 pts	+1 pts	+1.5 pts	**+2 pts**	+1.9 pts	+1.8 pts	+1.7 pts

5. [6 pts] Explain the typical process of becoming a professionally licensed engineer and maintaining a professional engineering license. [2 pts] 0.4 pts each for the 5 following elements (ok to elaborate):
BS degree from ABET accredited program; pass FE exam → 4 yrs of increasingly responsible practice under a licensed PE → take and pass the PE exam;
after PE, in many states, continuing education is required

Discuss how this might change in the future and why. [1 pt]
might be required to earn an MS degree or 30 additional credits of coursework prior to being allowed to sit for PE exam (0.5 pts)
Why? Declining credits to earn BS degree in engineering vs. historically; more breadth of knowledge to learn, such as professional skills; more technical depth of knowledge to learn in focused specialty areas of practice; brings engineering more in line with requirements in other professions such as medicine and law (0.5 pts, full credit if list 2 or more reasons)

Discuss how this process helps to ensure that engineers can uphold their ethical responsibilities to protect human and environmental health and welfare. [1 pt] {full credit for something reasonable here}
Engineering education must include breadth and learning about people/society, but must also accommodate more technical knowledge; just too much to learn in a 4-yr bachelor's degree; without sufficient education, cannot design processes that protect human and environmental health/welfare

{your answer should be about 300-500 words long; Figure 1 in the BOK summarizes this process, but your answer should provide more detail on these basic steps}
2 pts for correct overall length of response (300-500 words)

>60% too short	40-60% too short words	20-40% too short	10-20% too short	0-10% too short	Within rec word limits	10-20% too long	20-50% too long	>50% too long
0 pts	+0.5 pt	+0.7 pts	+1 pts	+1.5 pts	**+2 pts**	+1.9 pts	+1.8 pts	+1.7 pts

6. [6 pts] Write 200-400 words to summarize your thoughts about the ASCE *Body of Knowledge for Civil Engineering, 2nd Ed*. You may want to discuss 1 or more of the following issues: did you read anything in the BOK that surprised you? Were there any important skills, knowledge, or attributes that appeared to be missing? (for your consideration, you may want to explore the international engineering BOK). Does the vision of civil engineering presented align with your expectations? Inspire you?

Able to discuss any of suggested elements about reading the BOK2. Reasonable answers 4 pts for content.

2 pts for correct overall length of response (300-400 words)

>60% too short	40-60% too short words	20-40% too short	10-20% too short	0-10% too short	Within rec word limits	10-20% too long	20-50% too long	>50% too long
0 pts	+0.5 pt	+0.7 pts	+1 pts	+1.5 pts	**+2 pts**	+1.9 pts	+1.8 pts	+1.7 pts

ABET Student Learning Outcome: Contemporary Issues

CVEN 4897 Professional Issues in Civil Engineering, Fall 2016
<u>ASSIGNMENT 5: Case Study Sustainability:</u> Hurricane Katrina and New Orleans

Rubric

Total points earned of 80 max (technical elements)	Poor	Need Improvement	Adequate	Superior
	55.9 or less	56 to 63.9 pts	64 to 71.9 pts	72 or more
	Demonstrates poor ability to apply Envision rating system, used to promote sustainable infrastructure		Lacks complete understanding of application of Envision as a contemporary tool endorsed by ASCE to promote sustainable infrastructure	Demonstrates understanding of sustainability, and the current rating system that ASCE is promoting to measure it (Envision)

The recovery and rebuilding activities in New Orleans after Hurricane Katrina pre-dated the ASCE's ENVISION sustainability rating system for infrastructure. However, we can analyze the reconstruction plans and activities to explore the extent to which sustainability was considered.

1. Using ENVISION v. 2.0, Discuss how the planning and/or rebuilding activities could earn credits under the QUALITY OF LIFE Category. Select <u>two</u> of these credits, explain each, and give specific examples of how the post-Katrina rebuilding would have qualified for these credits. [14 pts]
   7 pts per credit. Should be clear which credit they selected (see summary table below) (1 pt), explanation of how the credit can be earned should be clear (3 pts). Specific example of how New Orleans post-Katrina rebuild fits this credit should be clear (3 pts) {grade a reference that supports this example from post-Katrina below under "references"}

1	QUALITY OF LIFE	PURPOSE	QL1.1 Improve community quality of life
2			QL1.2 Stimulate sustainable growth and development
3			QL1.3 Develop local skills and capabilities
4		COMMUNITY	QL2.1 Enhance public health and safety
5			QL2.2 Minimize noise and vibration
6			QL2.3 Minimize light pollution
7			QL2.4 Improve community mobility and access
8			QL2.5 Encourage alternative modes of transportation
9			QL2.6 Improve site accessibility, safety and wayfinding
10		WELLBEING	QL3.1 Preserve historic and cultural resources
11			QL3.2 Preserve views and local character
12			QL3.3 Enhance public space

2. Using ENVISION v. 2.0, Discuss how the planning and/or rebuilding activities could earn credits under the LEADERSHIP Category. Select <u>two</u> of these credits, explain each, and give specific examples of how the post-Katrina rebuilding would have qualified for these credits. [14 pts] {same grading guidelines as Q1; 7 pts each credit+example}

13	LEADERSHIP	COLLABORATION	LD1.1 Provide effective leadership and commitment
14			LD1.2 Establish a sustainability management system
15			LD1.3 Foster collaboration and teamwork
16			LD1.4 Provide for stakeholder involvement
17		MNGMT.	LD2.1 Pursue by-product synergy opportunities
18			LD2.2 Improve infrastructure integration
19		PLANNING	LD3.1 Plan for long-term monitoring and maintenance
20			LD3.2 Address conflicting regulations and policies
21			LD3.3 Extend useful life

3. Using ENVISION v. 2.0, Discuss how the planning and/or rebuilding activities could earn credits under the RESOURCE ALLOCATION Category. Select <u>two</u> of these credits, explain each, and give specific examples of how the post-Katrina rebuilding would have qualified for these credits. [14 pts]

{same grading guidelines as Q1; 7 pts each credit+example}

22	RESOURCE ALLOCATION	MATERIALS	RA1.1 Reduce net embodied energy
23			RA1.2 Support sustainable procurement practices
24			RA1.3 Use recycled materials
25			RA1.4 Use regional materials
26			RA1.5 Divert waste from landfills
27			RA1.6 Reduce excavated materials taken off site
28			RA1.7 Provide for deconstruction and recycling
29		ENERGY	RA2.1 Reduce energy consumption
30			RA2.2 Use renewable energy
31			RA2.3 Commission and monitor energy systems
32		WATER	RA3.1 Protect fresh water availability
33			RA3.2 Reduce potable water consumption
34			RA3.3 Monitor water systems

4. Using ENVISION v. 2.0, Discuss how the planning and/or rebuilding activities could earn credits under the NATURAL WORLD Category. Select <u>two</u> of these credits, explain each, and give specific examples of how the post-Katrina rebuilding would have qualified for these credits. [14 pts] {same grading guidelines as Q1; 7 pts each credit+example}

35	NATURAL WORLD	SITING	NW1.1 Preserve prime habitat
36			NW1.2 Protect wetlands and surface water
37			NW1.3 Preserve prime farmland
38			NW1.4 Avoid adverse geology
39			NW1.5 Preserve floodplain functions
40			NW1.6 Avoid unsuitable development on steep slopes
41			NW1.7 Preserve greenfields
42		L&W	NW2.1 Manage stormwater
43			NW2.2 Reduce pesticide and fertilizer impacts
44			NW2.3 Prevent surface and groundwater contamination
45		BIODIVERSITY	NW3.1 Preserve species biodiversity
46			NW3.2 Control invasive species
47			NW3.3 Restore disturbed soils
48			NW3.4 Maintain wetland and surface water functions

5. Using ENVISION v. 2.0, Discuss how the planning and/or rebuilding activities could earn credits under the CLIMATE AND RISK Category. Select two of these credits, explain each, and give specific examples of how the post-Katrina rebuilding would have qualified for these credits. [14 pts] {same grading guidelines as Q1; 7 pts each credit+example}

49	CLIMATE	Emission	CR1.1 Reduce greenhouse gas emissions
50			CR1.2 Reduce air pollutant emissions
51		Resilience	CR2.1 Assess climate threat
52			CR2.2 Avoid traps and vulnerabilities
53			CR2.3 Prepare for long-term adaptability
54			CR2.4 Prepare for short-term hazards
55			CR2.5 Manage heat islands effects

6. Discuss how economic considerations should be added to sustainability evaluations. Explore the economic companion tools to ENVISION, such as the Business Case Evaluator. [10 pts]

Discussion logical and makes sense. Business Case Evaluator was presented in-class, so they should include some discussion of it. Overall quality of discussion.

ABET Student Learning Outcome: 12[j] Contemporary Issues
CVEN 1317: Introduction to Civil Engineering -- Homework 1

Answer the following questions based on researching the field of civil engineering from the Report Card for America's Infrastructure, Vision 2025, and the ASCE Body of Knowledge (BOK) for Civil Engineers (uploaded to D2L and available online at: http://www.asce.org/CE-Body-of-Knowledge/), http://www.ice.org.uk/what-is-civil-engineering, etc.) You may cite additional resources. Include in-text citations to support your responses and a final bibliography.

Learning goals:
1. Select a contemporary challenge in civil engineering that inspires your career goals

Question Used to Indicate Knowledge of Contemporary Issues
1. [15 points] Select a problem, need, or challenge facing society that inspires you to be a civil engineer. Describe the problem citing 1 or more appropriate references. The length of a good description should be about a half page. The ASCE infrastructure report card can provide ideas (http://www.infrastructurereportcard.org/), or look to current world issues, etc.

Grading criteria:

- *Description of the problem of adequate breadth and depth, relevant to CVEN, includes a few specifics. {8 pts} full credit if Problem was actually relevant to CVEN, description of sufficient breadth and depth with specifics; scale down for answer that is lacking these attributes*
- *Sufficient amount of discussion, indicated by length half page or more for full credit (when single spaced 12 pt font, 1" margins) {4 pts} [if only 25% of page long, only award 2 pts, etc.]*
- *Citation(s) provided for the societal problem {3 pts}*
    - *+2 points – clear where information came from;*
    - *+1 pt for ALSO sufficient citation information provided (author, year, etc; not just URL; this may be at the end but be sure also includes in-text citation to link to full information; footnotes also ok*

Rubric

Total points of 15 max	Poor	Needs Improvement	Adequate	Superior
	10.4 or less	10.5 to 11.9 pts	12 to 13.4 pts	13.5 pts or more
	Lacking both citation and problem description with sufficient detail	Lacking either depth in current problem description or citation	Identified a current problem relevant to civil engineering; expand depth or quality of citation	A contemporary problem relevant to civil engineering IDd and supported from current citation

ABET Student Learning Outcome: 14 Management, business, public policy, leadership

CVEN 4899: Civil Engineering Senior Project Design
Quiz

General Directions:

You have until 6:30pm today (4/25/17) to complete this quiz. Please do not exceed the sentence limit for short answer questions. You may reference the slideshows on D2L during this quiz. Any instances of plagiarism found (including verbiage from the guest speakers' presentations) will result in an automatic 0%. This quiz is an individual assignment, and must be completed entirely by you.

Scores will be out of two points for each question. (2 = Excellent, 1 = Mostly Correct, 0 = Poor)

Business Development – David Sharrock from A&P Construction

1. During a project pursuit, the lowest bidder traditionally wins. However, Mr. Sharrock mentioned other key components that clients might be willing to prioritize over cost. Describe two of those considerations.

Time/Schedule, conformance to instructions, experience, past job history, relationship, well thought-out plan, team composition.

2. When entering a meeting with someone, Mr. Sharrock stressed the need for intent. Please describe what he meant in one or two sentences.

Having intent in a meeting is having an outcome in mind, and setting forth a plan to accomplish that goal. Do prior research and brainstorm talking points before the meeting to make sure it's effective.

3. Why is common ground so important for establishing personal and professional relationships? What are examples that Mr. Sharrock used as possible sources of common ground? Use two or three sentences.

Common ground connects the individuals in a tangible way, creating trust and understanding. "It's what relationship are built on." Examples – skiing, golf, church, travel, etc.

Global Engineering, Environment and Societal Issues – Andy Logan from Brown and Caldwell

4. Dr. Logan mentioned six forces that are currently shaping the engineering industry. List them.

1. Population Growth
2. Aging Infrastructure
3. Climate Change
4. Technology
5. Availability of Natural Resources
6. Geopolitical Environment

5. Select one of these forces, and describe (in two or three sentences) how it is changing the future of the engineering industry.

1. Need for infrastructure and demand on resources / Concentration of people

2. Increasingly complex funding & engineering solutions required / System failures

3. Greater uncertainty / Need for resilient design

4. Greater efficiency & optimization / Global workforce & solutions

5. Global cost of energy / Investment in infrastructure / Competing demands on resources

6. Unstable environments/safety / Increased costs to deliver / Inability to fund projects

6. Give an example of one way a company or public utility could adapt to this force/impact, bettering their prospects of a successful future.

Answers will vary.

Ethics – Jon Jones from Wright Water Engineers

7. Name one institution that provides a "code of ethics" for professional engineers that Mr. Jones mentioned in his presentation.

ASCE, NSPE, AAWRE, ACEC, State P.E. Boards.

8. Above all else, what is an engineer's highest ethical responsibility? Use one sentence.

Serve the public.

9. What are 3 of the 4 reasons a person typically compromises his/her ethics (as described by Prof Morris)? Hint: Sara sat on the desk at the beginning of class to prove a point.

Time constraint, peer pressure, pressure from authority, monetary reward.

Industry Outlook, Personal & Professional Development – Rick Dutmer from FMI, and Bob Chapman from Brown and Caldwell

10. True or False: The current construction industry is growing more slowly than the overall economy.

False.

11. Mr. Chapman discussed his ideas about the difference between "doing" and "being". In two or three sentences, please describe this difference, and how you can use this idea to build your professional career.

"Doing" is the action of getting work done (i.e. working hard, being smart, producing high quality products and service), while "being" is composing yourself in a professional manner so you can build strong relationships. You need to center yourself between these two components in order to be the best employee/person you can. "What got you here won't get you there."

Leadership and Management – Professor Moorer from the University of Colorado

12. Dr. Moorer asked the class, "if you are leading a group, should you be 'friends' with them or 'friendly' with them?" What was his guidance and why?

A leader should be 'friendly' with those under his/her leadership, but not friends. When you are friends with someone, your personal relationship may sway your judgement when a tough decision is required.

13. Dr. Moorer discussed the differences between several different potential characteristics of a leader. Please discuss one of the comparisons he made which resonated with you most, and how it relates to the virtues of a good leader.

Answers will vary:

1. Love vs. Cynicism
2. Action vs. Progress
3. Humility vs. Arrogance
4. Vision vs. Reaction
5. Coach vs. Demand

Signature Attesting to Compliance

By signing below, I attest to the following:

That the Civil Engineering Program in the Department of Civil, Environmental, & Architectural Engineering has conducted an honest assessment of compliance and has provided a complete and accurate disclosure of timely information regarding compliance with ABET's *Criteria for Accrediting Engineering Programs* to include the General Criteria and any applicable Program Criteria, and the ABET *Accreditation Policy and Procedure Manual.*

_Robert D. Braun____________________
Dean's Name (As indicated on the RFE)

July 1, 2017

________________________________ ________________________

Signature **Date**