Sustainable Problem Solving Laboratory
Course 4

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In 1996, a fourth GE-sponsored course was offered within the School of Civil and Environmental Engineering. This course, the Sustainable Problem Solving Laboratory, was supervised by Dr. Jorge Vanegas, Associate Professor, School of Civil and Environmental Engineering. The course was co-developed and co-taught by Jennifer DuBose, Research Associate with the Center for Sustainable Technology; and Annie Pearce, Ph.D. Candidate, School of Civil and Environmental Engineering. 15 students participated in the pilot offering of the course during Summer Quarter 1996. The course integrated the instructors' expertise in context-based policy development and implementation, sustainability, and engineering problem solving and design. The students in the course were primarily seniors in Georgia Tech's School of Civil and Environmental Engineering who were interested in the concept of sustainability and wished to apply it to design problems as part of the engineering design requirements for their degree program.

The primary objective of the course was to provide students with a structured process for formulating, solving, and implementing solutions to engineering problems while incorporating the often-qualitative objectives of sustainability. Figure 1 shows a representation of the six-step problem solving process used to structure the class. Other learning objectives for the laboratory were to familiarize students with the concept of sustainability and its ramifications for design, decision making, problem solving, and engineering; to develop skills for interfacing with the public and presenting design recommendations; to strengthen written and oral communication skills; and to strengthen problem-solving skills, working both individually or in groups.

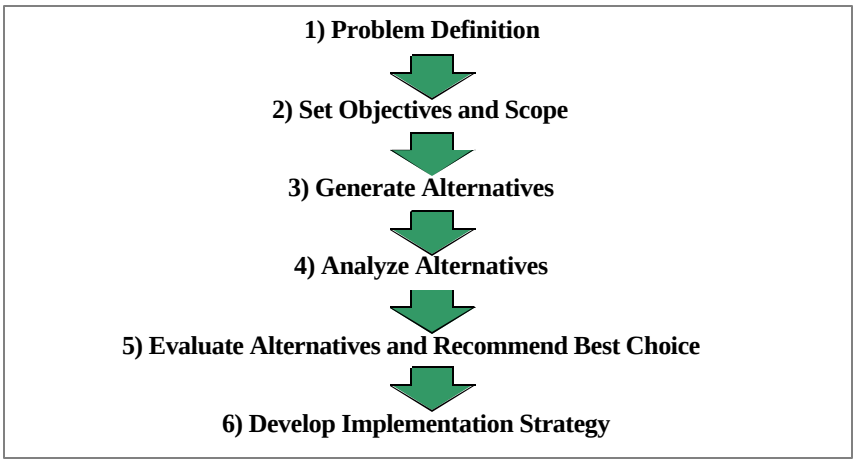

Figure 1: The Six-Step Problem Solving Process

The course was structured around quarter-long individual student projects, with the six-step problem solving process introduced throughout the course as students progressed with their individual projects. The first two class sessions were used to assist students in selecting project topics and scoping the projects to a manageable level that could be completed in a single quarter. A mandatory individual meeting of each student with the instructors was required at the problem scoping phase to assist each student in

defining a manageable problem to be solved. Students were encouraged to choose a problem by answering the question, "What irritates or inspires you most?" All problems chosen by the students were from the "real world" of engineering, and required interfacing with practitioners and members of the community outside the university.

Lectures, assigned readings, and in-class exercises provided the means for introducing students to the six steps of the problem solving process and allowed them to practice each step in the context of their self-selected engineering problems. The course provided a forum for developing professional written and oral communication skills by requiring a formal project report and presentation to be delivered to the instructors, who acted as mock "clients" of the student engineers "hired" to solve their specific problems. Guidelines for the final project report and presentation were provided to the students (see Appendix D-1) to link each step of the problem solving process to the problem investigated by each student. Students were encouraged to submit drafts of each section of the final report to the instructors for review and comment after each step of the problem-solving process was covered in the lecture. An electronic mailing list was established for the course to encourage students to post progress reports and interact outside of class to learn from the experiences of their classmates. The instructors also provided prompt written feedback on all interim submissions, and provided office hours by appointment to provide individual help as necessary.

Lectures 1 and 2, *Introduction* and *Finding Problems to Address*, introduced the students to the concept of sustainability, used examples of existing artifacts to show how design decisions have implications beyond the artifact being designed, and helped students to identify potential problems to be addressed in their term projects. Assigned readings for these classes included "Principles of Sustainable Development" (PCSD 1994), "Sustainable Technologies for the Building Construction Industry" (Vanegas et al. 1995), "Canon on Sustainability is Justified" (Veltrop 1995), and "A Compass for Sustainable Development" (Robert et al. 1996), to introduce the students to sustainability concepts in the context of civil and environmental engineering. Class exercises included interactive exercises on design critique for disposable beverage containers, and problem framing using an example of grocery bags. Students were required to submit short essays describing their answers to the question, "Who are you, and why do you care about sustainability?"

The next two lectures covered the topic of *Problem Definition*. In these lectures, videos and class discussions were used to introduce ideas for researching the problem, asking the right question, documenting information, establishing the context of the problem, identifying relevant issues, defining problem scope, working with people, and setting objectives and weightings. Assigned readings included selected portions of *Ecological Design* (Van der Ryn & Cowan 1996) and *Audubon House: Building the Environmentally Responsible, Energy-Efficient Office* (National Audubon Society 1994), to illustrate the kinds of objectives typically considered in sustainable engineering projects as well as the implications of context on selecting appropriate objectives. During this week, students were required to post brief descriptions of their proposed project topics to the course usenet group. Students also scheduled individual meetings with the instructors to discuss their proposed topics and to scope the projects to a level that could be completed for a single term project. Following these lectures, students were required to submit a draft of the first part of their final project report describing the scope and objectives of their term projects.

The fifth and sixth lectures focused on introducing students to methods for *Generating Alternatives* for solving their selected problems. In-class exercises included a drawing exercise to help students tap the creativity of their non-dominant brain hemisphere, small group brainstorming of solutions for student projects, and a video showing innovative solutions for Design for Disassembly used by the Daimler-Benz company. These lectures introduced students to seeing all sides of the problem, the affordances of designed artifacts, brainstorming techniques, systems thinking, and established strategies for industrial ecology, design for disassembly, and regenerative design. The purpose of class exercises and readings for

these lectures was to help students "think outside the box" and be non-critical of seemingly outrageous solutions which might hold promise for their term projects. Readings included selected portions of *Breakthrough Thinking* (Nadler & Hibino 1990), *Regenerative Design* (Lyle 1994), and "Industrial Ecology: Concepts and Approaches" (Jelinski et al. 1992). Following these lectures, the students each submitted a draft of the second part of their final project report describing the alternatives generated during brainstorming for solutions to their problems.

The seventh and eighth lectures, *Analyzing Alternatives*, provided an overview of existing engineering analysis methods relating to sustainability, including environmental impact assessment, life cycle analysis, feasibility determination, cost-benefit analysis, contingent valuation, and other metrics and criteria for sustainable design. Lectures were supplemented by a video on Life Cycle Costing for Built Facilities and an in-class debate on the price of life. Readings included selected portions of *Environmental Impact Assessment* (Jain et al. 1994), "Resource and Environmental Profile Analysis" (Hunt et al. 1992), "The History of a Cup of Coffee" and "An Order of French Fries" (Durning & Ayres 1994, 1995), "Changing Course: An Outline of Strategies for a Sustainable Future" (Corson 1994), and "Assessing Sustainability Projects" (AtKisson & LaFond 1994). Following these lectures, students submitted preliminary analyses of a selected set of feasible alternatives that they planned to consider for their term projects. These submissions constituted a first draft of the third portion of their final project report.

The ninth and tenth lectures, *Evaluating Alternatives*, provided a basis for helping students to systematically select solutions for their problems based on how well each considered alternative met the initial objectives for their problems. In these lectures, students revisited the initial sustainability and engineering objectives for their problems, and learned how to combine qualitative and quantitative information to comparatively evaluate each alternative solution. Guest lecturers from professional practice also provided discussion and information on how to present results to clients and the public, make recommendations, and target the appropriate audience for their engineering recommendations. In-class exercises in constructing objectives matrices demonstrated various methods for comparing alternatives. Assigned readings included "Pulling the Pieces Together: Amalgamation in Environmental Impact Assessment" (Elliott 1981), "Improving the Use of Information in Environmental Decision Making" (O'Hare 1980), and *Some Tips on Report Writing* (Reddy 1992). These readings demonstrated approaches for combining qualitative and quantitative information, as well as providing guidance for preparing and delivering the results of engineering analysis to clients and the general public. Following these lectures, students submitted drafts of their evaluation of potential solutions and recommended alternatives, comprising the first draft of the fourth portion of their final project reports.

Lecture 11, *Implementation Issues*, covered the topics of working within organizational constraints, developing implementation strategies, creating an implementation plan, and including and interfacing with the public. This lecture built on the topics introduced in lectures nine and ten, and introduced students to work breakdowns, cost and resource estimating, and other issues associated with implementing solutions to engineering problems. Assigned readings included "Strategic approach to transportation project implementation" (Lloyd & Meyer 1984), and selected portions of *Environmental Impact Assessment* (Jain et al. 1994), to provide examples and recommendations for implementing solutions and to introduce strategies for overcoming common barriers to successful implementation. Following this lecture, students submitted a draft of the final portion of their report, an implementation plan for their recommended solution.

The next two class sessions were used for student presentations of the results of their term projects. The class was provided with anonymous sheets to rate each presenter and to provide comments about presentation content and delivery. The final class session, *Wrap-up: Summary and Conclusions*, helped to tie the course together by answering the questions, "How has sustainability changed problem solving?", "What remains to be done?", and "What does the future hold?". This lecture also included student evaluations of the course content and delivery, and served as a forum for discussion and finding answers

to last-minute project-related questions. The final project report from each student was due during the week following the last class period. Table 1 shows the titles and a brief summary of the 15 student projects for the pilot course.

The students were required to submit their final reports in a format appropriate for a design portfolio, so that they could build their own portfolio in preparation for professional engineering practice. In two cases, the student reports were actually delivered to stakeholders in the real world and used in developing solutions. This course, while not a part of the original three-part series in sustainability, served as a focused forum for one discipline within the College of Engineering to further integrate the concept of sustainability into its curriculum. Student comments and long-term feedback about the course emphasized both the difficulty of solving problems with a fuzzy objective like sustainability, as well as the usefulness of having a structured problem solving process in developing sustainable solutions.

Table 1: Student Project Titles and Descriptions

Student	Project Title	Description
Anthony Cochran	A Sustainable Community Design for the Summerhill Area, Atlanta, GA	Recommended building new single family residential development to better serve the needs of this declining inner-city neighborhood
Julie Borchers	Sustainable Playground for Home Park Learning Center	Designed a site layout and recommended equipment constructed from waste materials for a low-budget child development center in a local neighborhood
Juan Bostwick	R.M. Clayton Wastewater Treatment Plant: Combined Sewage Overflow Problem	Recommended a design for additional flow storage capacity to handle stormwater overflow at Atlanta's main wastewater treatment plant
Raúl Perez-Veve	Analysis and Preliminary Design of Sustainable Power Generation Technologies for Hogar de la Esperanza de un Niño	Recommended a conceptual design for a photovoltaic power supply system for an orphanage in the Dominican Republic, Caribbean
Brian Thomas	The Future of Fire Station #11, Atlanta, GA	Examined alternative future uses for a decommis-sioned fire station in Atlanta's Midtown neighborhood
Nabeel Ahmed	Sustainable Modifications for Georgia Tech Plant and Operations in Terms of Energy Conservation	Explored options for improving the energy efficiency of Georgia Tech's physical plant operations
Kristine Hinesley	Sustainable Landscape Solutions	Recommended a landscape design utilizing xeriscaping and native plantings for a local Atlanta homeowner
Michael Stubbs	Sustainable Development Application to Organic Waste Disposal at Palisades Apartment Complex, Cobb County, GA	Recommended a design for a composting system to handle landscaping waste from a large apartment complex in an Atlanta suburb
Dean Golden	A Sustainable Solution to the Tenth Street Crossing	Recommended a design for a pedestrian crosswalk and new traffic light system at a dangerous intersection adjacent to the Georgia Tech campus

Student	Project Title	Description
Zachary Taylor	Feasibility Analysis to Provide a Sustainable Solution for Dredging Savannah Harbor	Recommended a design for an industrial ecosystem to make bricks from waste material dredged from the Savannah Harbor
Myra Monreal	Sustainability of Urban Neighborhoods: Improper Garbage Handling in Home Park, Atlanta, GA	Recommended a set of solutions for handling a neighborhood-wide garbage problem, including a central recycling facility, enforcement of waste container ordinances, and public trash cans
Omar Atkinson	Vine City Redevelopment Initiative	Recommended a redevelopment plan and neighborhood design for two city blocks in one of Atlanta's declining inner-city neighborhoods
Brittain Windham	Finding a Sustainable Solution to the Problem of the Biltmore Hotel	Recommended a renovation plan for a large, abandoned hotel in Atlanta's Midtown neighborhood
Amy Jones	Geotechnical Applications for Recycled Carpet Waste	Examined the feasibility of and recommended a plan for using fibers from recycled carpet waste to stabilize soil slopes and embankments
Joseph Harder	Good Mews Animal Foundation Sustainability Assessment	Recommended a series of sustainability improvements to the operational procedures and facilities of an animal shelter in suburban Atlanta

References

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National Audubon Society & Croxton Collaborative (1994). *Audubon House: Building the Environmentally Responsible, Energy-Efficient Office*. John Wiley & Sons, New York, 43-65.

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Jain, R.K., Urban, L.V., Stacey, G.S., and Balbach, H.E. (1993). *Environmental Assessment*, McGraw-Hill, New York.

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CE 4803B – Sustainable Problem Solving Lab

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TIME: Summer Quarter 1996
Lectures: To be announced

PLACE: Mason Civil Engineering Building; Room 312

CREDITS: 3 Credits (2 Design Hours)

ABSTRACT

This course provides an introduction to systematic problem solving and decision making using the principles of sustainability and sustainable design as guiding objectives. An introduction to sustainability with respect to problem solving will be presented, and a general framework for problem solving will be taught and demonstrated through projects both in and out of class. Tools, methods, and techniques for gathering information, generating, analyzing and evaluating alternatives, and developing implementation strategies will be presented and demonstrated. The course is intended to introduce students to the tools and mindset required for solving engineering problems sustainably, and to demonstrate sustainable problem solving for a real world problem. This course is part of a series of courses in sustainability sponsored by the GE Fund and the National Science Foundation.

TEXT AND REQUIRED READINGS

There is no required textbook for this course. Required readings and articles for the course will be distributed to students in class. A bibliography of these readings is listed in Attachment A. A list of suggested readings for students interested in expanding their knowledge of topics covered in this course is provided in Attachment B.

Additional reading material for the course will be made available as needed. A selected set of references on sustainability and sustainable design is available for short-term checkouts at the Center for Sustainable Technology administrative office in room 322 of the Mason building.

EDUCATIONAL OBJECTIVES

The principal educational objectives of the course are to:

1) familiarize students with the concept of sustainability, and its ramifications for design, decision making, problem solving, and engineering.

2) introduce students to a general approach for solving problems, and show how it can be applied to real world problems

3) acquaint students with the principal methods, tools and techniques used to solve design problems and synthesize solutions, and to acquire and process information.

4) develop specific skills for interfacing with the public, and presenting design recommendations.

5) develop a set of feasible solutions for a real world problem.

6) strengthen written and oral communication and presentation skills.

7) strengthen problem–solving skills, working both individually or in groups.

COURSE DESCRIPTION

The course includes a combination of lectures, assigned readings, class discussions, and one independent project and presentation.

Who should take this class?

All students who are interested in **applying principles of sustainability** to engineering design may take this class; the course is not limited to students with an engineering background. This course is another in the series of the undergraduate curriculum for sustainable engineering offered by the School of Civil and Environmental Engineering. There are no prerequisites for this course; however, prospective students are encouraged to take the other courses in the series to become more familiar with the principles of sustainability. Due to the self-designed nature of the independent project, this course is appropriate for both graduate and undergraduate students.

Lectures and Assigned Readings

The detailed list of lecture/discussion topics and assigned readings is contained in the Course Schedule (Attachment A). The lectures provide the conceptual framework for the course and supplement (i.e., not replace) the assigned readings. It will be to the students' advantage to complete the readings before the lecture date so that questions which may arise can be discussed more fully. Students are expected to have a working understanding of the lecture and reading materials, whether they are present in class or not.

Class Participation

Active class participation is expected and required, since the course will include extensive in-class discussions among students. Different ways of participating in the course include, but are not limited to: 1) contributing in an active way to class discussion of concepts and ideas; 2) presenting a brief summary and/or personal interpretation of reading materials upon the instructor's request; and 3) presenting issues from out-of-class projects for general discussion related to the topic at hand.

Class Usenet Newsgroup

A Usenet newsgroup has been set up for the purposes of this class. The newsgroup name is **git.ce.construction.sustainability_lab**. A brief introduction to Usenet will be given on the first day of class, but students are expected to become familiar with Usenet on their own. Students should be able to

access Usenet via their student accounts, read postings to the class newsgroup, and post messages to the group. Guidelines for posting messages can be found in the newsgroup net.user.newusers, and instructions for using various popular newsreaders can be obtained from OIT as well as on-line. All students are encouraged to read the newsgroup regularly, and use it as a communication forum for discussion of lectures, learning essays, and project information. Any questions about the class or its content should be posted to the newsgroup, and may be answered by either the instructors or other students in the class. Additional communication between students and the instructors is encouraged to take place via email.

Learning Essay

Students are required to submit a final learning essay at the end of the quarter. The purpose of this learning essays is to encourage you to: 1) absorb the information disseminated in class; 2) reflect on this information and consider how it may be applied to the your philosophies and practices with respect to sustainability; and 3) articulate the outcome of these reflections in written form. Content of the learning essay should include:

1) a summary of the important points you learned in the course.

2) personal reflections on what was learned and how this has influenced your thinking since the start of the quarter.

3) articulation of the most and least helpful aspects of the course in achieving your objectives.

The final learning essay should summarize what you have learned in the course, and how you will apply what was learned. This final learning essay will account for ten (10) percent of the final course grade.

Class Projects

There will be **one (1) project** to be completed over the course of the quarter. The purpose of this project is to provide students with an opportunity to apply the principles of sustainability and sustainable design to a real world problem of their own choosing. The project will also provide a chance for students to strengthen their general thinking, organizational, and written and oral communication skills. Because topics for the projects will be taken from the real world, students will gain valuable experience in dealing with the kinds of people and problems with which they will have to work upon entering professional practice.

Additional information about the nature and scope of the project will be provided over the course of the quarter. Students can expect the workload for the project to be fairly evenly distributed over the last five weeks of the quarters. The project will comprise seventy (70) percent of the final grade for the course. Students are encouraged to work in groups whenever appropriate for portions of their projects, since problems in the real world are almost always undertaken by teams rather than individually. The final report is required to be an individual effort. All team efforts which make up a part of individual projects must be appropriately documented as discussed in class.

Assignments

There will be seven individual and/or group assignments required throughout the quarter, some of which will serve as drafts for sections of the final project. Prompt review of each submission will be provided by the instructors. These comments should be useful to the students in preparation of the final project report. The quality and prompt submission of these assignments will serve as grading criteria. Together, the seven assignments will comprise 20% of the total grade for the course.

FEEDBACK AND GRADING

The breakdown of the total grade is:

• Final Learning Essay		10 %
• Out-of-class Project Draft		5 %
• Out-of-class Project		65 %
• Assignments		20 %
	Total:	100 %

The instructors will make every attempt to provide prompt feedback on all student submissions, either written or electronically. In addition, the instructors will specify open office hours for student questions and consultations. If appropriate, the instructors will institute an open door policy for student consultations. However, the primary forum for discussions, questions, and answers should be the class newsgroup on Usenet.

NOTES:

The course description and course schedule handouts provide the general framework for the course. However, the instructors reserve the right to make any modifications or changes to the course, depending on the class progress, or on any special circumstance that may arise during the quarter.

ATTACHMENT A: BIBLIOGRAPHY OF REQUIRED READINGS

[AtKisson 1994] AtKisson, A., and LaFond, M. (1994). "Assessing Sustainability Projects: A Prototype Rating System for Comparative Evaluation." AtKisson & Associates, Inc. Sustainable Development Series, Paper 1.

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ATTACHMENT B: LIST OF RECOMMENDED SUPPLEMENTAL READINGS

[Chechile & Carlisle 1991] Chechile, R.A. and Carlisle, S. (1991). *Environmental Decision Making: A Multidisciplinary Perspective.* Van Nostrand Reinhold, New York.

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CE 4803B - Sustainable Problem Solving Lab
Course Outline

Class	Topic	Activities	Readings	Assignments	Submissions
1 8/13	**Introduction** Course Objectives What is Sustainability? How Can We Make Design Decisions That Lead To Sustainability? Introduction to Usenet	Bottle Exercise Usenet Demo	PCSD (199x) Daly (1989) Van der Ryn & Cowan (1996) Veltrop (1995)	1: Who are you, and why do you care about sustainability?	
2 8/15	**Finding Problems to Address** What Irritates Or Inspires You Most? Sustainability Triangle Framing The Problem	Bag Exercise	Vanegas et al. (1995) Robert et al. (1996) Russo & Schoemaker (1989) CSWS (199x)	2: What problem are you going to address?	Assignment 1
3 8/20	**Problem Definition I** Researching the Problem Asking the Right Questions Documenting Information Context Of The Problem	Majo Bay Video	Federal Register (1973) Reyna (1991)		Assignment 2
4 8/22	**Problem Definition II** Identifying Relevant Issues Defining Problem Scope Working with People Setting Objectives and Weightings	Earthship Video	Van der Ryn & Cowan (1996) Audubon House (1994)	3: Set scope and objectives for project	
5 8/27	**Generating Alternatives I** Seeing All Sides of the Problem Gibsonian Affordances Brainstorming	Drawing on the Right Side Bottles Revisited	Nadler & Hibino (1990)		
6 8/29	**Generating Alternatives II** Systems Thinking Strategies: Industrial Ecology, Design for Dissassembly, Regenerative Design	Mercedes Benz Video	Lyle (1994) Jelinksi et al. (1992) Nadler & Hibino (1990)	4: Generate alternatives for project	Assignment 3
7 9/3	**Analyzing Alternatives I** Environmental Impact Assessment Life Cycle Analysis Feasibility Determination	LCC Video	Jain et al. (1993) Durning & Ayres (1994,95) Hunt et al. (1992)		
8 9/5	**Analyzing Alternatives II** Cost-Benefit Analysis, Contingent Valuation Metrics and Criteria	Price of Life Exercise	Hammel (1994) AtKisson (1994) Corson (1994)	5: Conduct analyses of potential alternatives	Assignment 4
9 9/10	**Evaluating Alternatives** Revisiting Objectives Comparative Evaluation of Feasible Alternatives	Objectives Matrix	Elliott (1981) O'Hare (1980)	6: Evaluate feasible alternatives in terms of initial objectives	Assignment 5
10 9/12	**Presenting Alternatives** Presenting Results and Making Recommendations Targeting the Appropriate Audience	Sample Presentations	Meyer (199x) Reddy (1992)		Out-of-Class Project Draft Review
11 9/17	**Implementation Issues** Working within Organizational Constraints Developing Implementation Strategies Creating an Implementation Plan Including and Interfacing with the Public	Guest Speakers: Mike Meyer Bill Patton	Lloyd & Meyer (1984) Jain et al. (1994)	7: Develop implementation plan for recommended alternative	Assignment 6
12-13 9/19 9/24	**Project Presentations**				Assignment 7
14 9/26	**Wrap-up: Summary and Conclusions** How has Sustainability Changed Problem Solving? What Remains to be Done? What does the Future Hold?	Course Evaluations			Final Learning Essay
				FINAL PROJECT SUBMISSION: SEPT. 30....	

Appendix D-1:

Final Project Report Guidelines

Executive Summary

This section of the report should contain a brief overview of the report, including problem statement, summary of relevant background information, brief description of methodology and objectives, and final outcome of the work.

Part 1: Introduction

This section of your report should include a summary description of the problem you are addressing, a specific and concise problem statement, a description of the scope of your investigation, and a summary of the methodology you have used to address the problem.

Part 2: Background and Problem Definition

This section of the report should include a discussion of the history and background information you have collected which relates to your problem, with ***appropriate documentation*** of all your information sources. A discussion of the problem stakeholders and their concerns should be included, along with the objectives you've developed for the problem, any assumptions you are making, and a review of existing solutions which have been tried for this problem. This section of the report should conclude by presenting a concise and detailed description of the problem and its scope as you've chosen to frame it for your investigation, in preparation for generating alternative solutions as discussed in Part 3.

Part 3: Generation of Alternatives

This section of the report should document the process you undertook to generate alternative solutions for your problem as defined in Part 2. The first part should be a presentation of the results of brainstorming about your problem, followed by a discussion of how and why you ruled out alternatives from the initial list of solutions, leading to the set of solutions you have decided to consider for analysis. The section should conclude with a description of each of the solutions you have selected for further investigation.

Part 4: Analysis of Alternatives

This section of the report should include a discussion of the results of your detailed development and analysis for each alternative. Analysis may include, but not be limited to, a detailed description of each prospective alternative, sketches, diagrams, maps, sample calculations, or whatever supporting information is necessary to give the reader a clear understanding of the nature of the alternative needed to proceed to the evaluation phase of the design (i.e., comparison in terms of initial objectives, economics, environmental impacts, and social/cultural impacts).

Part 5: Evaluation of Alternatives and Recommended Solution

This section of the report should include a comparative evaluation of the potential alternatives analyzed in Part 4, both in terms of sustainability and with respect to the initial objectives developed in Part 2. The section should begin with a reiteration of the initial objectives, and discuss the costs and benefits of each alternative in terms of economics, environment, and social/cultural impacts, as well as the technical feasibility of each potential solution. A recommended medium for performing the evaluation is a weighted objectives matrix comparing how well each solution meets each of the objectives. The section should conclude with a recommendation to pursue one of the proposed solutions, which is ***clearly supported*** by the analysis and evaluation.

Part 6: Proposed Implementation Strategy for Recommended Solution

This section of the report should contain a proposed strategy for implementing the solution you recommend in Part 5. The section should include a discussion of the key players who will be involved in implementation, the roles they will play, the tasks necessary for implementation, the estimated resources and time requirements needed to complete each task, and potential barriers to implementation that are anticipated. This section should include an estimated conceptual budget and schedule for implementing your recommended solution.

Part 7: Evaluation of Project and Conclusions

This section of the report should serve to summarize the work you've done and identify for the reader any opportunities for future work which have resulted from your efforts. The section should contain a summary of the outcome of your design process, an overview of the anticipated impacts and benefits of your recommended solution, any comments you have about how effective the solution may be, and a discussion of areas for further work. It should end with a discussion of the conclusions you've drawn as a result of your project.

References

This section of your report should contain complete and correctly formatted citations for all material from other sources referenced in your report. ASCE format is recommended; however, you may use other standard citation formats as long as you are consistent and complete.

Attachments

This section of the report is optional. Attachments should be included to show detailed or repetitive calculations, raw data which are too big to be included directly in the report (but should be summarized in the appropriate section), specialized or unique information which supports the body of the report and cannot be easily obtained in a library, or other appropriate supporting information. Do ***not*** include material in the attachments just to "bulk up" your report, and be sure that any information you include as an attachment is referred to in the body of the report at least once.

Evaluation Considerations

In evaluating your report, we will be concerned mainly with understanding the process you followed in generating your recommended solution, and the clarity, logic, and completeness with which you present your results. Since you are all current or future engineering professionals, we expect you to be able to present your work in a coherent, readable format, without spelling or grammatical errors. We recommend that you follow the outline presented, and be careful to include all the information requested for each section. However, each of your projects is unique, and only you can determine the appropriate level of detail and information which should be included as a part of your report. As you are writing, imagine that you are competing with other design professionals in trying to convince the appropriate stakeholders that your recommended solution should be chosen. The better you present your work, the more likely it is that your solution will be understood and selected, and the better your final grade will be. We will be happy to review your work and provide comments over the next five weeks to help you improve the final product