Constructing Environmental Impact Statements: An Organizational Focus for Teaching Analytical Environmental Chemistry

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Abstract

Chemical analyses should always be accompanied by activities that ensure and document quality control (QC). An undergraduate course in environmental analysis is a practical point at which to teach this as the US EPA has developed a standard set of QC activities. Such a course should be a requirement for all environmental chemistry programs as the collection of reliable and defensible data is central to regulatory monitoring work as well as modeling efforts and risk assessment. In the environmental realm, QC includes activities associated with sampling, sample preservation and storage, method validation and analysis involving solids, liquids, and gases. Students should be led to discover the need for QC by first performing analyses with little guidance followed by a class discussion in which they critique their data. Once convinced of the value of QC, students learn specific techniques by performing an Initial Demonstration of Capability for a relatively simple analysis in which they perform an instrumental calibration, determine method detection limits, and demonstrate adequate precision and accuracy. Particular focus is put on the use of spreadsheets for generating forms, producing control charts and performing statistical tests. A variety of analytical methods are covered including: atomic and molecular spectrometry, ion selective electrodes and gas chromatography.

Introduction

In 1994, the American Chemical Society promulgated guidelines for approval of degree programs in environmental chemistry. These include "at least two semesters (*i.e., courses*) of advanced work in chemistry of the environment, including some aspects of aquatic, atmospheric, and geochemistry"(1). This increased interest in teaching environmental chemistry at the undergraduate level has led to the publication of numerous textbooks that support lecture-based courses (2-7). In contrast, relatively few manuals exist to support a companion lab-based course (8-10). This is largely due to the traditional emphasis on analyte measurement so that the lab manual is primarily a cookbook of analytical techniques. These manuals are either very vague or tailored to a particular brand and model of instrument and thus are of limited utility.

An alternative focus is described herein, organizing an environmental chemistry laboratory course around a class project in which an Environmental Impact Statement (EIS) is constructed. This approach is based on the efforts of Haynes et al. (1983) who have developed a similar curriculum for a mixed graduate-undergraduate summer field ecology course (11). Environmental assessment being the goal, data collection is one component of a series of integrated activities (planning, sampling, analysis) used to generate scientific data. Students then use these data to perform an environmental assessment in the format of an EIS. Data validation techniques are used during sampling and analysis but are minimal as this subject is better dealt with in a companion course devoted to learning US EPA-approved techniques for sampling, analysis and quality control (12).

What's an EIS?

Environmental impact assessment (EIA) is now a common requirement in most countries with the common goal being to ensure that environmental quality is not significantly compromised as a result of a proposed industrial, commercial and/or government project. The United States was the first to formulate an explicit requirement for an EIA as part of its National Environmental Policy Act (NEPA) of 1969 (13). NEPA stipulates that the federal government is responsible to "minimize adverse environmental impacts and to preserve and enhance the environment as a result of federal plans and program," thus mandating a far loftier goal of environmental enhancement as compared with other countries. NEPA also established the United States Environmental Protection Agency (US EPA) which was given wide executive powers to formulate and enforce a series of other pivotal laws including the Clean Air, Clean Water, and Safe Drinking Water Acts. It also established the Council on Environmental Quality (CEQ) which, as part of its charge, coordinates federal compliance with NEPA.

Section 102 of NEPA (42 USC 4332(c)) specifies that federal agencies include in "proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official." This detailed statement is now referred to as an Environmental Impact Statement (EIS). The phrase "human environment" refers to "the natural and physical environment and the relationship of people with that environment" including any related economic or social effects. Many states now have their own set of enabling legislation requiring that a similar type of environmental assessment be done for projects using state funds as well as for some large-scale commercial projects.

Federal actions that trigger the EIS requirement include issuance of federal permits as well as federal funding and assistance. Thus any private, state, or local project, which accepts federal funds or assistance or requires federal permits, must have an EIS prepared. Some categorical exceptions include actions that will never have a significant effect or those conducted by the US EPA itself. In equivocal cases, such as ones in which it is unclear as to whether the potential impacts could be significant, an Environmental Assessment (EA) is first conducted. The EA produces a short document containing sufficient evidence and analysis for determining whether an EIS need be prepared. For most minor actions, the EA results in a "Finding of No Significant Impact" (FONSI) or "Negative declaration" and hence no EIS is prepared. If a "Positive Declaration" results, the next step in EIA is preparation of an EIS.

The EIA process is directed by the US EPA in conjunction with federal agencies that have jurisdiction over permits required for some part of the proposed project. For example, a permit from the Army Corps of Engineers is required for any projects that potentially affect the navigability of waterways. In some cases, these agencies will play the lead role in the EIA process.

NEPA stipulates that "(A)n EIS is intended to provide a full and fair discussion of significant environmental impacts and shall inform decision makers and the public of reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment" with the intent being to assess impacts on the entire ecosystem as well as on human resources. The CEQ has recommended a structure and content for an EIS. As shown in Table 1, the EIS starts with a description of the action and an inventory-like description of the affected environment including biological, geological, cultural and economic characteristics. This is followed by a discussion of land-use relationships in which the proposed project is placed in the context of existing land-use plans, policies and controls, such as local zoning ordinances. This information is used to make projections as to the likely pollution to be generated by the proposed project. This should include a qualitative as well as quantitative estimate of direct as well as indirect impacts over a range of temporal and spatial scales. Mathematical models are the preferred means for predicting pollutant transport and its impact on biota. This analysis must be done for all feasible alternatives including a "No-Build Option". A discussion of possible mitigation efforts that could counteract at least some of the negative impacts is also required. Special emphasis is put on identifying impacts which permanently and irretrievably impair resources as well as the consequences of this loss on humans and the environment. Thus an EIS is fundamentally a comprehensive risk assessment for the human population and ecosystem.

As described below, the EIS goes through both internal and external reviews that include periods of public comment before being used by the government to determine whether or not a significant impact is a likely consequence of the proposed project. If the finding is of no significant impact, the result is permission to proceed with the project along with approval of permits granted by other governmental agencies.

Benefits

The advantages to organizing an environmental chemistry laboratory course around production of an EIS are:

•The environmental assessment process is experiential and hence requires students to be actively engaged rather than passively performing unlinked weekly lab assignments. Lab activities require application of lecture concepts to discussing, assessing and resolving environmental problems identified by the students' analytical results. Along the way, students discover the difficulties and shortcomings in the current approaches to environmental assessment and management.

•Students are motivated to produce higher quality analytical data if they know the data are a necessary element of the EIS. Additional motivation can be achieved if the EIS is to be read and used by others. For example, high quality data can be used in future classes to trace temporal trends in water and sediment quality. The resulting EIS can be useful to others beyond the classroom and the institution, including community, environmental and local business groups.

•Students must engage in collaborative efforts all through the semester on a class level as well as with their lab partner from sampling, to analysis, to writing and defending the EIS. This requires development of time management skills as well as of negotiation and cooperation.

•In preparing and defending the EIS, students must practice their writing, speaking and literature searching skills with the latter including the use of the Internet.

•As shown in Table 2, construction of an EIS is a highly marketable skill. After having gone through the exercise of preparing and defending one, students are in a better position to consider careers in the field of environmental planning which could include specialized graduate training. Chemistry majors do not traditionally consider these career options or graduate programs and hence benefit from a personal experience with the field.

•This experience prepares and motivates students to continue their training in environmental chemistry. As per American Chemical Society guidelines, we have developed a second course for our environmental chemistry majors, which focuses on techniques for sampling, analysis and data validation (12). Students who have first taken the EIS-based course have a much easier time with the second, as they are comfortable with the basic sampling and analytical techniques and thus can concentrate on the finer points of data validation. In an effort to get as much data as possible to assess temporal trends for the EIS, students in this second course use the same sampling sites for collection of their samples and measure many of the same analytes.

Selection of an Appropriate Project

Selection of an appropriate project is critical to the success of this curricular approach. We use completion of our University's Campus Master Plan for the following reasons:

•The University has already published a short document describing planned construction activities and contains data tables of square footage, costs, timing, etc. Also included are maps of wetlands, storm water drainage, landscaping, parking, and buildings. These maps were generated with Geographical Information Systems software (GIS) so a digitized base map is available for class use. Access to other institutional documents as well as campus officials involved in the proposed project is also readily available.

•Our campus is relatively small (about 4600 students) making completion of our Campus Master Plan a relatively minor action. Thus the potential impacts are sufficiently limited in scope to enable the EIA process to be performed in one semester.

•Using a local project expedites sampling as students are geographically familiar with the site and travel time is minimal as are access and safety issues. Site familiarity also facilitates analysis of land-use relationships, as students are usually aware of the campus' geological and biotic characteristics as well as drainage patterns.

Using the campus plan is interesting to students, as this is a project that directly impacts their current (hopefully) primary activity and future alma mater. It It also provides a problem that generates an immediate conflict in environmental decision making. Typically, students start the semester with the presumption that any development or construction is bad because it results in an environmental impact. Since the students know that our enrollment is increasing, they are forced to acknowledge that some construction must occur, especially of more parking spaces. Their personal contact with the pros and and cons of construction make it easier for them to generate a balanced EIS.

Table 1. CEQ-prescribed EIS Content (14)

- I. Project Description
  - A. Purpose of action
  - B. Description of action
    - 1. Name
    - 2. Summary of activities
  - C. Environmental setting
    - 1. Environment prior to proposed action
    - 2. Other related Federal activities
- II. Land-use Relationships
  - A. Conformity or conflict with other land-use plans, policies and controls
    - 1. Federal, state and local
    - 2. Clean Air Act and Federal Water Pollution Control Act Amendments of 1972
  - B. Conflicts and/or inconsistent land-use plans
    - 1. Extent of reconciliation
    - 2. Reasons for proceeding with action
- III. Probable Impact of the Proposed Action on the Environment
  - A. Positive and negative effects
    - 1. National and international environment
    - 2. Environmental factors
    - 3. Impact of proposed action
  - B. Direct and indirect consequences
    - 1. Primary effects
    - 2. Secondary effects
- IV. Alternatives to the proposed Action
  - A. Reasonable alternative actions
    - 1. Those that might enhance environmental quality
    - 2. Those that might avoid some or all adverse effects
  - B. Analysis of alternatives
    - 1. Benefits
    - 2. Costs
    - 3. Risks
- V. Probable Unavoidable Adverse Effects which cannot be avoided
  - A. Adverse and unavoidable impacts
  - B. How avoidable adverse impacts will be mitigated
- VI. Relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity
  - A. Trade-off between short-term environmental gains at expense of long-term losses
  - B. Trade-off between long-term environmental gains at expense of short-term losses
  - C. Extent to which proposed action forecloses future options
- VII. Irreversible and irretrievable commitments of resources
  - A. Unavoidable impacts irreversibly curtailing the range of potential uses of the environment
    - 1. Labor
    - 2. Materials
    - 3. Natural
    - 4. Cultural
- VIII. Other Interests and Considerations of Federal policy that offset the adverse environmental effects of the proposed action
- IX. Countervailing benefits of proposed action
- X. Countervailing benefits of alternatives

Table 2. Job Ads for Environmental Impact Assessors

Environmental Planner Environmental Careers Bulletin (9 Sept 1997, p. 8) ..(seeking) an individual with a bachelor's degree in environmental studies, planning, physical sciences or related field. Knowledge of CEQA, NEPA, Endangered Species Act and other environmental laws and regulations; ability to produce technical report sections ; excellent technical writing and problem solving skills; 1+ years experience with environmental regulations; knowledge of WordPerfect, Excel, and database programs; and experience in California with private consulting firm	**Risk Assessment Research Assistant** Environmental Careers Bulletin (5 May 1998, p. 10) Assist in design and analysis of tasks for research projects; conduct literature and data searches; perform analysis under guidance of senior staff; and write reports. Reqs: bachelor's degree in chemistry, biology, environmental science, environmental engineering or math; outstanding academic record excellent writing and analytical skills; good oral communication skills; and proficiency with PC-based spreadsheet and word processing program. Familiarity with principles of exposure and risk assessment a plus.
Environmental Specialist Environmental Careers Bulletin (9 Sept 1997, p. 5) ..(seeking) an individual to sere as an authority on matters pertaining to the preparation and submission of Environmental Impact Assessments/ Environmental Impact statements as related to general biology, botany, and zoology. Coordinate EIA/EIS with Federal, State, and local officials as required to insure that regulations are complied with, and concerned agencies are aware of current actions being taken; review short, mid, and long range environmental plans in consonance with all Federal, State, and local laws; exercises an extensive knowledge of the procedures used in planning and programming pollution abatement projects and provide the administrative direction and control, and recommend counter-proposals that provide the most feasible and economical solutions when proposed projects will have adverse effects on the environment. Reqs: bachelor's degree in biological sciences, agriculture, natural resource management, chemistry, or related field; knowledge of environmental regulations; ability to project future environmental reqs.; and knowledge of procedures of pollution abatement.	**Senior Environmental Planner** Environmental Careers Bulletin (9 Sept 1997, p. 7) ..(seeking) an individual with knowledge in NEPA documentation, Section 404 permitting, and other federal regulatory environmental requirements; BS in Environmental Planning, Management, and/or Science…. **Risk Assessment Research Assistant** Environmental Careers Bulletin (9 Sept 1997, p. 13) Support human health/ecological risk assessments. Conduct literature and data searches; perform analyses under the guidance of senior staff; and write reports. Reqs: BS degree in chemistry, environmental science, environmental engineering or math; outstanding academic record. 0-2 year experience in the field of environmental science; excellent writing and analytical skills, good oral communication skills, and proficiency with PC-based spreadsheet and word processing program; familiarity with principles of exposure and risk assessment is a plus.

Lab Manual

An in-house lab manual is used as a text to cover techniques of environmental assessment and construction of an EIS as well as the analytical part of the course. An outline for this manual is shown in Table 3 (15). This manual is also used for our second environmental chemistry course, which emphasizes sampling design, analytical techniques and data validation. Alternatively, students can be assigned readings on the EIA process from sources including some available through the WorldWide Web (16-18).

The details of EIS construction are presented on a need-to-know basis with most of the introductory material covered during the scoping process as described below. Thus students should be assigned the reading in Part I (see Table 3) prior to the scoping activity. The remainder of the information is covered at the end of the semester just prior to the actual writing of the EIS

Scoping Process

The environmental assessment process is started with a planning phase referred to as "scoping". This is reproduced in the classroom by having students read a short document describing the proposed project. This is followed by a class discussion in which students "scope" the project by identifying the range of actions, alternatives and impacts that need to be addressed. Three types of actions must be considered (connected, cumulative and similar) and three types of alternatives (no action, build alternatives and mitigation measures) as well as three types of impacts (direct, indirect and cumulative).

Issues that are likely to be insignificant are eliminated. Since small projects are not likely to have many significant impacts, they are best for classroom use as many elements of the EIS can be omitted or reduced in scope. To assist in identifying which topics need to be included in the EIS, class discussion can be directed with a scoping checklist. An excerpt is provided in Table 4.

Sampling

Given a list of potential impacts, students can then focus on developing sampling objectives. Our students are usually most interested in assessing the impact of storm-water runoff on environmental quality in the campus wetlands. They readily identify the need to determine pollutant levels in water, sediment and organisms. Before going any further, the class takes a reconnaissance trip in which an in-situ probe, such as a Hydrolab™, is used to measure basic water-quality characteristics, including temperature, dissolved oxygen, conductivity, pH and turbidity
as these aid in understanding drainage dynamics. Students are also shown the sampling sites used in previous semesters. Revision of these sites is usually necessary due to construction activities and variations in water-table level.

Following this field trip, a sampling plan is devised in which recognized compromises are made. For example, not everything can be measured in their samples, so students must select key analytes to focus on. Students also recognize that performing the same analyses as in years' past provides access to a long-term data set for studying temporal trends. As the selected analytes cannot all be measured at the same time, either the samples must be preserved or resampling performed. While the former can work for some analytes, others must be analyzed within a short period. For example, alkalinity must be measured within 24 hours of collection. Thus sampling is done just prior to lab analysis. While this eliminates the need to preserve the samples, students recognize that later interpretation of the data will be confounded by possible temporal changes in environmental conditions. Finally, the number of sampling sites has to be limited enough to enable students to complete all the analytical work within a 3-hour lab session. Two approaches can be used for weekly sample collection, either assignment of sample sites or rotation of sampling duties. The latter is burdensome as the teacher has to monitor the rotation and students will have a lengthy sampling activity if the campus is large. By assigning sampling sites, students do a better job at resampling the correct locations especially if special equipment, such as a grab sampler or a remotely closed water-sampling bottle, is needed.

Surface water can be sampled by simply dipping and filling a container. Other alternatives include attaching a bottle to an extendable pole (hose clamps work well for this). Sub-surface sampling requires use of a remote-closing sample bottle, such as a Niskin™ or Go-Flo™ bottle. These bottles must be deployed from a hydrowire. Shallow sediment sampling can be done with a plastic pipe using the sampler's hand to create enough vacuum to hold the sediment in place during recovery. An even easier approach is inverting a self-sealing plastic bag over the sampler's hand, grabbing a handful of sediment and pulling the sample inside the bag to enable closure. For sediments significantly below the water surface, a lightweight grab sampler is recommended.

Sampling on public lands often requires a permit from a state's department of natural resources. While explicit permission to sample on campus should be obtained, no formal permit is usually required. The teacher also has some assurance of the relatively safety of the student's sampling without direct supervision

Analysis

Since the focus of the class is on interpreting and using data, analytical details need to be minimized. Hence analytes which are relatively easy to measure should be selected. Examples are provided in Table 5 along with the US EPA method number and a short description of the instrumental technique. These methods are published by the US EPA and are required for regulatory work (20-24). The teacher should provide direction as to requisite data validation activities. These should involve calibration (including method blanks) as well as analysis of sampling and analytical replicates. Where applicable, recovery should be checked using reference material which can be obtained from companies who manufacture standards for

environmental analyses. Analytical time can be further reduced using kits, such as those from Hach™ and LaMotte™. Kits, albeit expensive, are also available for bioassays of organic compounds such as BTEX, PCB's, etc.

Data Reduction

Weekly lab results are submitted in a traditional lab report format. This information is pooled and presented by the teacher to the class in a brief weekly review. This provides an opportunity for students to critique each week's worth of data as well as to begin interrelating the results of the different analytes. Lab work is completed three weeks before the end of the semester. At this time, the students are given a master spreadsheet containing all the data and are asked to prepare a presentation about a particular set of analytes. These presentations are held in the succeeding week in the format of a workshop/conference.

Students prepare their presentations in pairs for which a group of related analytes, such as pH and alkalinity, is assigned. To ensure that essential topics are covered, students are provided with a checklist of items that their presentation must include. For example, they must look for temporal trends using statistical tests, such as ANOVA. To enable this, past class reports are placed on reserve in the library. Students must also research appropriate U.S. EPA environmental-quality criteria for their analyte so that they can determine which sites have exceeded these limits. Because we are able to provide students with a GIS base map, their data can also be plotted in a geographic format.

At the data conference, presentations are approximately 10 minutes long leaving a few minutes for questions. A projector is used to display graphics created with Microsoft Office's Powerpoint™ into which graphs and data tables from Excel™ can be imported. The data conference is concluded by construction of a master table summarizing the temporal trends by analyte as well as identifying which analytes exceed U.S. EPA environmental-quality criteria. Using the feedback received during their oral presentations, students prepare a written report on their analytes. These are compiled into one report prefaced by the master table and made available to the class for construction of their segments of the EIS.

Writing of the EIS

At the next class meeting after the data conference, the students are organized to write the EIS. Each pair of students is asked to prepare one or two elements of the EIS. These groups meet one-on-one with the teacher for advice on information sources which can include governmental documents as well as people, such as the campus planner. These documents should be collected in advance as most are not commonly available. Likewise, the teacher should alert any people to whom the students are likely to approach for assistance.

The most important sections of the EIS are the discussion of alternatives and potential impacts. The latter should refer to the scientific and analytical bases used, such as the accumulated data as well as any statistical tests or modeling efforts. Due to time limitations, modeling is difficult to perform. A more practical alternative is to use matrices to compare the relative scale of impacts.

After one week, during the last week of the semester, each group meets with the teacher to review their progress. The EIS assignments are submitted on the last class day. The teacher then compiles the results to generate the EIS. The students are required to review the entire EIS in preparation for their mock public hearing that is held during the final exam week. Due to the large size of the document, copies are placed on reserve in the library.

Mock Public Hearing

Public participation is a critical part of the EIA process under NEPA which stipulates that the public be given access to a draft of the EIS and then be allowed to submit comments. While a public hearing is not required, these are usually held for large and/or controversial projects. Comments on the draft EIS are used to produce a second document, referred to as the final EIS. The US EPA, or lead agency, then makes a judgment regarding impacts by issuing a record of decision (ROD). The ROD contains either a Finding of No Significant Impact (FONSI) or a finding of significant impact. It must also state the basis for the decision, identify all alternatives considered, specify the environmentally preferable alternative and explain any requirements for avoiding or mitigating environmental harm. For class use, these steps are compressed into a public hearing of the draft EIS in which comments are voiced and the project proposers given an opportunity to respond. The judges review all the information and then issue a ROD.

The public hearing is held during the final exam week and thus the last class day is used to organize the event. To do this, the students are provided with a one-page document that serves as a public notice of the time and date of the hearing. It also contains a schedule of activities (Table 6) as well as rules for the hearing. The teacher is assigned the role of Hearing Office at Arms and thus is the enforcer of the rules. This way the teacher can ensure that the process is concluded within the two hours blocked out for the final exam.

Students can either be assigned or select their own roles. The teacher should give each student some informal advice as to how to play his or her part (Table 7). For example, students should be encouraged to act out their role, i.e. play devil's advocate even though they might not agree with their role's assigned point of view.

Students have really enjoyed the public hearing to the extent that during one event, some coordinated with the departmental assistant to interrupt the proceedings with delivery of a dead (stuffed) rabbit in support of a stakeholder's argument regarding the likelihood of extreme negative environmental impacts. This led to a heated debate regarding the statistical validity of making a conclusion from a single rabbit, dead of uncertain causes.

The public hearing is also an excellent opportunity for students to discover flaws and limitations in the environmental assessment process. Most important is that students understand even the most comprehensive, sophisticated EIS will not necessarily lead to selection of the most environmentally protective alternative. This is largely because the lead agency generating the ROD is not being requested to select the environmentally preferable alternative, but only to explain the rationale for selecting a less environmentally protective alternative. Thus the success of the EIA process in protecting and enhancing the environment lies in the subjective process of assigning a
significant human value to environmental amenities. Extant environmental standards, such as those for drinking water, are often the only hard scale against which the importance of an impact can be set.

Students should also be led to engage in a debate regarding what constitutes a true assessment. As in the real world, lack of time, data and money reduce this phase of their process to a biogeochemical inventory and list or matrix of potential impacts. Even in the best of situations, such as when models are used to perform a risk analysis for estimating the probability of environmental impact, the results are often questionable due to lack of data or limited sophistication of the model. Especially difficult to model are long-term and secondary (indirect) impacts and thus these are usually ignored.

Students should also be led to appreciate the important role that citizen input, especially from those with scientific training, plays in the EIA process. Since this process is lengthy and complicated, it is important to understand where and how citizen input can be most effective. Finally, students discover that while they can readily generate an EIS that contains all the required components, it is quite another matter to generate one that complies with the spirit of NEPA. They should come to realize that the only way to achieve this is to perform a sophisticated risk analysis based on solid scientific principles. Equally important is establishing the relative value to humans of environmental amenities. This is best done by the people who are to be directly impacted, i.e. the local citizens.

Grading and Student Feedback

Students earn a lab grade that is an average of their performance on the weekly lab reports, their final oral and written data presentations as well as their written segment of the EIS component. The performance during the mock public hearing is counted as part of their class participation effort, all of which is applied as extra credit.

Student feedback to this organization of the environmental chemistry lab has been very positive. The few negative comments have included suggestions that guest speakers be invited to class and that trips to environmental quality labs be scheduled. The teacher's biggest complaint is the lack of time in which to perform modeling exercises. One way to address this would be to coordinate with other courses. Courses in ecosystem analysis or differential calculus are good ones for tackling modeling projects. Some institutions, such as ours, also offer classes designed to teach modeling to science majors.

Other ways to do an EIS

Other approaches can be used to provide students with the experience of preparing an EIS or at least dealing with issues of risk analysis and management that are the fundamental underpinnings of environmental decision-making. In classes without a laboratory component, an Environmental Assessment (EA) can be performed rather than a full-blown EIS. An EA contains a discussion of the need for the proposed action, information regarding the environmental impact of the action, a limited discussion of the alternatives to the action and a list of agencies and persons consulted in preparing the document.

Preparing an EIS can be an excellent opportunity for non-science and science majors to interact. For example, Honors Programs often offer a capstone seminar for their students. Preparing an EIS in such a setting could use the skills and interests of the business, economics, sociology, archaeology, statistics, and applied math as well as science majors. Each group would then be involved in relevant modeling efforts and be charged with writing relevant parts of the EIS.

Alternatively, students can be charged with preparing a personal EIS. The goal of the personal EIS is to have a student evaluate their lifestyle from a resource-use perspective while considering costs and benefits of other alternatives as well as potential mitigation approaches (Carl Pratt, Dept of Biology, College of New Rochelle, private communication). Other ways of performing environmental assessment include evaluating projects on a case study basis or teaching the process of risk analysis as a discrete part of a curriculum (25-27)

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Table 3. Lab Manual Format

- I. Environmental Assessment
  - A. National Environmental Protection Act
  - B. Environmental Impact Statements
    - 1. CEQ-prescribed EIS Content
    - 2. Check lists
      - a) Determining Project Size
      - b) Identifying EIS components relevant to proposed project.
  - C. Proposed Project
    - 1. Description
    - 2. Maps
    - 3. Summary of past analytical results
- II. Data Validation
  - A. Statistical Methods
  - B. Quality Assurance/Quality Control Practices
  - C. Chain of Custody
- III. Sampling
  - A. Plans
  - B. Equipment
  - C. Sample Collection & Preservation
- IV. Analytical Methods
  - A. In-situ measurements
  - B. Inorganic Analytes
  - C. Organic Analytes

Table 4. Excerpt of Scoping Checklist (19)

- IV. Alternatives to the Proposed Action
  - ❑A. Alternative Design and Technologies
    - 1. Site Layout
      - a) Density and location of structures
      - b) Location of access routes, parking and utility routes
    - 2. Orientation
      - a) Compatibility with slope and drainage patterns
      - b) Site size and setback requirements
    - 3. Technology
      - a) Pollution control equipment
      - b) Innovative vs. proven technologies
    - 4. Mix of activities
      - a) Addition of businesses which would affect the operational nature of the facility
  - ❑B. Alternative sites
    - 1. Limiting factors
      - a) Availability of land
      - b) Suitability of alternate site to accommodate design requirements
      - c) Availability of utilities
      - d) Suitable market area
      - e) Compatibility with local zoning and master plan
      - f) Compatibility with regional objectives
      - g) Accessibility of site to transportation routes and the service population
  - ❑C. Alternative Size
    - 1. Increase or decrease project size to minimize possible impacts
    - 2. Increase or decrease project size to correspond to market and community needs
  - ❑D. Alternative Construction/Operation Scheduling
    - 1. Commence construction at a different time
    - 2. Phase construction/operation
    - 3. Restrict construction/operation work schedule
  - ❑E. Alternative Land use
    - 1. Suitability of site for other uses
      - a) Other types of commercial uses
      - b) Other types of industry

Table 5. Recommended Analyses

Analytes per Week	EPA Methods	Instrumental Techniques
Temperature, Dissolved Oxygen, Conductivity	EPA 170, 310.1 and 360.1	In-situ. Variety of probes available at price ranges from a few hundred dollars to $7K.
Color, Turbidity, Coliforms	EPA 110, EPA 180.1 and SM_{18} 9222	For true color, measure absorbance at 450 nm after filtration. For turbidity, measure reflectance with turbidity meter (field equipment available). Coliforms by membrane filtration technique using commercially available sterilized filters, petri dishes and media. Incubation can be done in drying oven if appropriate humidity is maintained.
pH and Alkalinity	EPA 310.1 and 345.2	Gran-type titration using pH meter to detect endpoint
Hardness, Ca and Saturation Index	EPA 130.2, 215.2 and APHA 2330	Total hardness with EDTA titration using Erio-T as indicator. Ca hardness using murexide as indicator. Mg hardness by subtraction. Speciation computer program used to compute SI.
Fluoride and Chloride	EPA 345.2	Ion selective electrode (non-standard method for Cl)
Nitrate and Phosphate	EPA 353.3 and 365.2	Beer's Law using colorimeter or spectrophotometer to measure absorbance. Recommend use of fiber-optic probe to eliminate glass cuvettes and hence reduce time of absorbance measurement to a few seconds.
Dissolved and Soil Trace Metals (Takes 2 - 3 lab sessions)	EPA 200 series	Dissolved metals by flame atomic absorption spectrophotometry. Method of standard additions used to eliminate matrix problems. Trace metals leached from sediments using acid digestion performed in either open beakers on a hot plate or teflon bombs in microwave oven.
Chlorinated Pesticides or Petroleum Hydrocarbons	EPA 508, 608, 525, 624 and 1664	Petroleum Hydrocarbons by extraction into solid-phase cartridges or filters. Elution into hexane. Quantitation by Beer's Law using FT-IR. Pesticides by extraction into solid-phase cartridges

Table 6. Public Hearing Activities

Activity	Role Player
Call to Order	Officer at Arms (teacher) armed with gavel
Reading of Rules and Presentation Schedule	
Presentation of Proposed Project	University President , Campus Planner and EIS Consultant
Presentation of Scientific Findings	EIS Consultant and Governmental Permitting Official(s)
Stakeholders	As listed in Table 7. Five-minute presentations each.
Rebuttal	University President , Campus Planner and EIS Consultant
Decision by Judges	Judges recess to prepare ROD.
Reading of Record of Decisions (ROD)	Judges return and read the ROD.

Table 7. Public Hearing Roles

Role	Point of View
Judges (putting them in graduation robes is fun)	Responsible for drafting ROD. Three needed to break a tie.
Hearing Officer at Arms (teacher)	Keeps process on schedule.
University President	Make project presentation and perform rebuttal. These roles support the project
Director of Campus Planning	
EIS consultant	
Governmental Permitting Official(s)	NEPA requires all federal agencies with related jurisdiction or special expertise to comment on issues in the EIA within their areas of competence. These roles then represent government agencies such as the US Fish and Wildlife Service and the US Army Corps of Engineers and are not necessarily supportive of the project.
*Faculty Senate President	Represents the interests of the faculty.
*President of Student Government Association	Represents the interests of the students.
*Wetland Ecologist	Represents independent scientific experts.
*President of Homeowner's Assoc.	Represents the interests of local homeowners.
*Local Business Owner	Represents the interests of local business owners.
*Chair of Local Sierra Club Chapter	Represents the interests of environmentalists.
*Concerned Citizen	Represents self interests.

*Stakeholders