HAAS

PROCEEDINGS

Fourth Conference on Environmental Engineering Education

Editors

James W. Patterson and Roger A. Minear

June 19–21, 1980
University of Toronto
Canada

Conference Sponsors

American Academy of Environmental Engineers
Association of Environmental Engineering Professors

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ACKNOWLEDGEMENTS

Appreciation is expressed to the many individuals who contributed to the preparation for and implementation of the Fourth Conference on Environmental Education, and to the assembly and publication of these proceedings. Particular gratitude is due Dr. Barry Adams and his collegues of the University of Toronto, and to Mrs. Gloria Posilovich who assisted the Conference Chairman in the day-to-day chores which are required in organizing any conference.

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INTRODUCTION

In 1960, the First Study Conference on Sanitary Engineering Education was held at Harvard University. The Conference was sponsored by the American Sanitary Engineering Intersociety Board (later the Environmental Engineering Intersociety Board EEIB, and now the American Academy of Environmental Engineers, AAEE). This conference was the first organized effort by academicians and practioners of the profession then termed "sanitary engineering" to address key issues influencing the depth, scope, and quality of existing educational programs. The conference produced recommendations on sanitary engineering education which have now become an integral part of modern environmental engineering academic programs.

In part as a result of the impetus arising from this First Conference, the American Association of Professors in Sanitary Engineering, AAPSE (now the Association of Environmental Engineering Professors, AEEP) was organized in December, 1963. In 1967, seven years after the founding conference, the Second National Conference on Environmental and Sanitary Engineering Graduate Education was sponsored by EEIB and AAPSE at Northwestern University. As with the First Conference, this second effort was organized around a set of themes, or focal issues, perceived by the profession as critical to the effective education of the environmental engineer. This conference established the concept of environmental engineering as an interdisciplinary profession based on the engineering and applied science disciplines for which man and his well-being are the principal focus.

The Third National Conference on Environmental Engineering Education was held in August, 1973, at Drexel University, under the same sponsorship as the Second Conference. This conference addressed a broad range of focal issues on manpower and programmatic needs at both the graduate and undergraduate level. The conferences recognized that in the few years since the 1967 Second Conference, as the nation entered the era of the Environment, the scope and dimensions of environmental engineering problems had changed dramatically, and the Conference was dedicated to an examination of the educational requirement to prepare environmental engineers to meet the challenges of the decades ahead.

In 1978, the American Academy of Environmental Engineers, and the Association of Environmental Engineering Professors directed that planning be initiated for the Fourth Conference on Environmental Engineering Education to take place in 1980. Environmental pollution doesn't recognize national boundaries, and environmental engineering is practiced internationally. The Fourth Conference was international in scope and these proceedings reflect the contributions of practitioners from a dozen countries throughout the world.

CHAIRMAN'S PREFACE

In 1978, the officers of the American Academy of Environmental Engineers, and the Association of Environmental Engineering Professors directed that planning begin for the Fourth Conference on Environmental Engineering Education. A Conference Steering Committee was established to plan and coordinate the conference.

Steering Committee

J. W. Patterson, Chairman
P. W. Purdom, Advisor
R. A. Minear, Secretary
R. F. Christman
G. P. Hanna, Jr.
J. G. Moore, Jr.
A. T. Rossano
R. F. Weston

The Steering Committee met several times for the purpose of organizing and coordinating the various aspects of the conference. It was decided to hold the conference during the period of June 19-21, 1980, at the University of Toronto, Canada. The Fourth Conference thereby immediately preceded the 10th International Conference on Waste Pollution Research (June 22-27, Toronto) and the Annual Conference of the Air Pollution Control Association (June 22-27, Montreal). The timing and site of the Fourth Conference on Environmental Engineering Education was thus chosen to encourage maximum participation by North America and overseas engineers and scientists. This strategy was successful and nearly 100 academicians and practicing professionals representing 12 countries participated in the Conference.

The Steering Committee selected four focal issues to be addressed at the Fourth Conference and established Task Groups to prepare background position papers addressing each issue. The Focal Issues and Task Groups Co-chairmen are listed below:

- Excellence in Environmental Engineering Education

  Perry L. McCarty, Co-chairman
  Charles R. O'Melia, Co-chairman

- Comprehensive vs Specialist Programs in Environmental Engineering Education

  Paul L. Busch, Co-chairman
  Daniel A. Okun, Co-chairman

- Curricular Balance in Environmental Education

  Ernest F. Gloyna, Co-chairman
  Hal B. Cooper, Jr., Co-chairman

- Relationship of Baccalaureate to Graduate Environmental Engineering Education

  Donald B. Aulenbach, Co-chairman
  James P. Heaney, Co-chairman

Task Groups, under the direction of the Co-chairmen, prepared draft position papers for review and comment. Final draft position papers were then prepared for distribution at the Fourth Conference. These position papers provided the background documentation for the Discussion Groups formed at the Conference to consider the Focal Issues, and to produce discussion group reports and recommendations to the Conferees in Plenary Session. The position papers, discussion groups reports, and plenary conference session actions are contained in this document.

In preparation for the Conference, status papers on the state of environmental engineering education were commissioned for presentation at the opening session of the conference. The objective of these status papers was to present data on four aspects impacting on environmental engineering education. The four aspects are:

- Programs, Degrees and Faculty
- Student Enrollment Trends and First Employment
- Manpower Needs in Environmental Engineering
- Funding for Graduate Student Support

These papers provided a valuable context for the subsequent consideration of the focal issues by the conferees. Because of the usefulness and significance of the data contained therein, the four status papers are also included in this document. The conferees benefitted from presentation by two internationally recognized overseas educators at the opening session. Dr. Werner Stumm spoke on the topic, "Environmental Engineering and Environmental Science: The Inseparable Partnership," and Dr. Rolf Kayser presented a "European Perspective on Environmental Engineering Education."

As is obvious from this preface, many individuals and organizations were involved in the preparation, organization, and accomplishment of the Fourth Conference on Environmental Engineering Education. These contributors have performed a valuable service to our profession, and their efforts merit our recognition.

James W. Patterson
Conference Chairman

KEYNOTE ADDRESS

WHAT PRICE THE FURBISH LOUSEWORT?

by

LORD ERIC ASHBY

Before you embark on the technical papers for this Conference, let me tell you two stories, each with a moral. For the first, I take you back 88 years and transport you from Toronto to London. In the British parliament the Lord Stratheden and Campbell is introducing, for the tenth time in six years, a Bill to abate smoke in London. It has been a winter of dense sulphurous fogs; visibility reduced sometimes to no more than a yard; traffic paralysed, even walking along the streets at times impossible. The stuff seeps into theatres so that the audience cannot see the stage.

No one in the parliament of 1892 is ignorant of the facts about fog. The politicans often had to grope their way through fog to get there. They had learnt from dozens of speeches what causes the fog, what damage it does, how it could be prevented. They are now going to be asked, for the tenth time in six years, to pass a law to abate it.

Industrial smoke from boilers generating steam was already controlled by law in the Metropolis; these London fogs were caused mainly by domestic fires from nearly a million homes, burning a high sulphur coal.

Lord Eric Ashby, a Fellow of the Royal Society, has received 21 honorary degrees recognizing his contributions both as a scientist and as a leader in higher education. Lord Ashby served as President of Queen's University, Belfast, and as Vice-Chancellor of Cambridge. He is currently Chancellor of Queen's University, Belfast. Lord Ashby is a past president of the British Association for the Advancement of Science, and was the first chairman of the Royal Commission on Environmental Pollution. He was a Harkness Fellow at the University of Chicago, Godkin Lecturer at Harvard University, and Walgreen Professor of Human Understanding in 1976-77 at the University of Michigan. Lord Ashby's most recent book is RECONCILING MAN WITH THE ENVIRONMENT.

The damage was obvious: smoke corroded metal and stonework and it killed as many people as were killed in outbreaks of cholera; a death less dramatic only because it was insidious and delayed. During three weeks in the winter of 1880 over 2,000 Londoners died from ailments attributable to the fog.

The smoke could be prevented simply by giving up the use of soft coal in open fires and heating homes by closed stoves burning coke or anthracite coal. This was the way homes were heated on the Continent, though in some countries it was easier to do because there was a plentiful supply of wood which could be used instead of coke or hard coal.

The hazards of smoke were evident, the nuisance of it blighted the city, the cure was at hand. But (I now take you back into the parliament of 1892) Lord Stratheden and Campbell again fails to get his bill approved. Worse than that, he is ridiculed by the Prime Minister, Lord Salisbury. The bill proposed to make it an offense for a householder to allow opaque smoke to issue from his home. How, says the Prime Minister, do you define the word "opaque?" Defining it would "give infinite pleasure, amusement, and occupation to Her Majesty's Courts of Justice." "I do not know whether my noble friend thinks he would ever get Parliament to pass such a measure as this, or whether he would get the English people to obey it if it were passed." It would condemn Londoners to live in homes where they would never see a fire with a flame in it. "I do not think" he went on, "that, for the sake of avoiding an occasional inconvenience, grave as it is (not a very felicitous way to describe dying from bronchitis) for a certain number of days in the winter, people would condemn themselves to a flameless fire all the winter through." He continues his ridicule: "Conceive of an inspector going to every house in London and seeing that the grate was properly fitted in order not to emit smoke. The burden . . . would be worse than the London fog." The bill was rejected. The British people, through their legislature, had done an implicit cost-benefit analysis. For the benefits of what one journal described as an "open, pokeable, companionable fire," they were prepared to pay the cost of a higher death rate, the long drawn out misery of respiratory diseases, blackened and crumbling stonework, dirt on windows and curtains, a "daily increasing sacrifice of daylight to dirt."(1)

Why do I tell you this story? In it lies a high priority problem in engineering environmental education. I have no doubt that engineers who have to make policy decisions about the environment are well qualified in the technology of conservation and pollution control. They know how to build flood barriers, abate smoke, treat sewage, design power plants and reservoirs. They know about the hazards to the environment which arise from exploitation by man: acid rain, rivers bereft of oxygen, impoverished vegetation and wildlife. They know also about the hazards to man which arise from abuse of the environment: soil erosion, threats to the ozone layer, accumulation of noxious substances like DDT residues and mercury. In these areas, I believe education is by and large adequate, though this Conference may well improve it. What is lacking from education is analysis of that intangible entity we call public opinion and of the impact of public opinion on policy making. How do people do this cost-benefit calculation between a companionable open fire and a menacing pea soup fog? How do they distinguish between acceptable and unacceptable risks? How is it that prejudice so often overrides common sense? Confronted by public attitudes such as this, how can the trained environmental engineer best put his expertise at the disposal of society? Before I answer this last question, here is my second story. This one is in the 1970s and much nearer home. It is familiar to some of you already.

The U.S. Army Corps of Engineers plans to build a $1.2 billion hydroelectric dam on the St. John River in Maine. It is not a region of virgin wilderness; it has been lumbered for timber since the 1840s. Pulp mills and potato farms lie along the river. But on the steep banks of the river, precariously perched between white spruce and downy alder, there grows a rare plant, discovered by an amateur botanist, Kate Furbish, in 1880 - just 100 years ago - and named after her the Furbish Lousewort.

If the Corps of Engineers builds the dam, the Furbish Lousewort is likely to become extinct. At any rate, that is what conservationists say. So under the Federal Endangered Species Act, President Carter was obliged to halt progress on the dam; the decision was recorded in the eighth annual report of the Council for Environmental Quality for 1977.(2)

This is not an isolated freak incident. There is the much publicized triumph of a little fish, the snail darter, which held up the building of the Tellico dam in Tennessee; and in Britain in the 1960s both houses of parliament were engaged in a long controversy to decide whether or not to allow a reservoir to be built in a remote valley in Teesdale. The benefit was to be an impressive expansion of industry at the Tees estuary in an area blighted by unemployment. The cost was that the dam might endanger the relics of an alpine flora, including a rare plant called the Teesdale sandwort. The dam was built, but only after delay and bitter controversy (and, incidentally, the Teesdale sandwort still flourishes there).[3]

A century or so ago, when the railroads were driven through the land and industry sprawled into the countryside, the idea of pitting the snail darter, the sandwort, and Miss Furbish's Lousewort against a major engineering project would have been regarded as crazy. Not so today. The title of this address - What Price the Furbish Lousewort? - stands for a new kind of cost-benefit analysis. On one side of the balance are masses of quantitative data, technology assessments, computer outputs, scale drawings, blueprints. On the other side are unquantified symbols of another life-style: a companionable open fire, a rare plant, a marsh visited by migrating birds. And, to the dismay of some engineers and administrators, the unquantified symbols sometimes tip the scale. To study how and why this happens is - in my view - an essential ingredient in the education of environmental engineers. It is clear that environmental engineers are already well aware of this. In all four position papers circulated to us there is reference to the problem. Let me quote from one of them, the paper by Aulenbach and Heaney's work group: "The finest technical solution to a problem is worthless if it cannot be explained or sold to the public and consummated."

Now I shall draw the morals from these two stories. I begin by offering you a sobering string of negatives. In applying his expertise to environmental problems, the engineer cannot rely on persuasion by hard data; quantification isn't enough. He cannot assume that the response to his carefully argued case will be rational; logic penetrates the head, but not the heart, and many of these issues are settled in the heart.

He had better not hope for consensus; most environmental issues are conflicts between one kind of good and another kind of good; they are not simple duels between good and bad. We lack efficient institutions for the management of this kind of conflict. And - as though this were not a forbidding enough catalogue - the

Furbish Lousewort (representing nature) has a lesson to teach the environmental engineer (representing industrial man) which industrial man disregards at his peril.

Now let me deal with these assertions one by one.

Quantification is not enough.
There was a time - it's over now - when cost-benefit analysis was regarded as a reliable technique for making choices in such matters as the siting of airports, motorways, power plants, and reservoirs. Economics is about the logic of choice, and cost-benefit analysis is a favorite tool of economists. Imponderables such as noise, disruption of the skyline, the hazards of smoke, and amenities of wilderness - none of these dismayed the economist. He found ingenious ways to qualify them. How much would you pay to put in double glazing to cut out the racket of trucks; or for that matter, how much would you pay to move away from the noisy neighborhood altogether? What is a reasonable compensation for having to repaint your home once a year or for enduring the inconvenience of bronchial attacks brought on by smoke and sulphur dioxide? What price the risk of your death on a highway without crash barriers? What price the preservation of the Furbish Lousewort?

To all these questions economists are willing to supply ingenious (but, in my view, utterly implausible) answers. Thus, for a huge dam proposed for the Delaware River at Tocks Island, the benefits were reckoned to amount to $29 million a year (of which over a third was an estimate of the profits from tourists at $1.35 per tourist-day); and the cost, including discount, was reckoned at about $18 million a year. So - provided you attach no importance to the intrinsic beauty of the river at Tocks Island, no importance to the fact that the Delaware River is the only river on the Eastern seaboard not to have been disfigured in this way, no importance to the stress caused to the people who would be displaced from their homes - the cost-benefit analysis promised annual profits of $11 million a year. Advice, therefore, was: build the dam.

In the event, there is no dam at Tocks Island, nor is there likely to be one, for two reasons. The minor reason is that the cost-benefit analysis is wrong. Neglected factors such as road building to the site, change in discount rate and so on, make nonsense of the original arithmetic. But that's only the minor reason. The major reason is that the imponderables tipped the scale when a political decision had to be made. And we now know the reason for this. It isn't just that cost-benefit analysis is unreliable when it involves projection into a distant future - though this is true; it is also - and this is the decisive educational point - an inappropriate technique. It sets out to answer the question: what is efficient for society? But this is not the question the public asks about environmental issues nowadays: they ask what is good for society? And the most precious kinds of good cannot be quantified without distortion.

There is another reason why quantification is not enough and indeed is sometimes counterproductive; namely the way it may drive the public into disillusion and resentment. In Britain our procedure for public participation over environmental issues is under the Town and Country Planning Act. The relevant Minister conducts a public enquiry at which any citizen - without having to engage a lawyer - can give evidence. The trouble about these enquiries is the risk that they will be David-Goliath affairs. The proponent of the scheme has access to expertise and cash. At the enquiry he smothers the public with highly sophisticated evidence which mystifies and ultimately enrages them. Over setting the route for a motorway, for instance, the transport authority flourishes a cabalistic number called COBA which is derived from a string of variables fed into a computer. The COBA-value identifies the optimum route for the motorway. But - and I come back to the importance of studying how public opinion evolves - the reaction to COBA has been vigorous protest which reduced some public enquiries to a dogfight. Why? Because you find that COBA, once you insist on dissecting it, hides assumptions repugnant to the ordinary citizen. When you enquire exactly what data are fed into the computer for traffic density, time saved, risk of accidents, noise, disturbance of the landscape, and so on, you find this sort of thing:

(a) If Route A compared with Route B saves one second, then it is assumed that 3,600 drivers each saving one second are the equivalent of one driver saving an hour. And (b), the estimate of the cost of a death saved is $94,000, a figure resting on the flimsiest of evidence. Despite inflation, Englishmen are apparently cheaper than Canadians (where the assumed cost of a fatal accident is about $134,000, and even cheaper than Americans (where it is about $160,000).(4) The seminal question is this: in making environmental impact assessments is it better to restrict economic analysis to values that are unquestionably quantifiable, leaving the decision maker to integrate the imponderables into the decision by subjective means? Or is it better to stretch economic analysis to cover values which have to be stripped of their human meaning in order to quantify them? The education of an environmental engineer should bring him face to face with this issue.

Rationality is not enough.

On the top floor of the Athenaeum Club in London - the Valhalla of intellectuals - there are bedrooms where members can stay overnight. The bedroom between No. 12 and No. 14 is labelled 12a, and this although some of the members are scientists or engineers. I have never seen evidence that there is a higher mortality or morbidity rate among persons who are born on the 13th of the month, or who travel on the 13th, or who sleep in a room numbered 13; but the highly intelligent members in this temple of rationality are taking no chances. It's a pretty reminder that man does not live by rational thought alone. So the engineer who gets involved in policies for the environment has to take account of a second difficulty.

Not only are policies likely to be influenced by unquantified variables; e.g., the tranquillity and clarity of water in a river may be reckoned more important than its coli count or its acidity or its phosphate content, but even quantified variables are not interpreted rationally by the public. There was an example of this recently in Britain. The Medical Research Council published in the last week of March, 1980, the most thorough investigation ever made in Britain of the impact of lead on health. This, combined with a study published in 1978 by the Atomic Energy Authority on lead from automobiles, gives a clear quantified picture of the sources of lead and their pathways into human beings.(5) I'll not digress to give you the details of this; it's enough to say that lead from the air accounts for only 11 per cent of an adult's total intake of lead and that the most dangerous sources of lead in Britain are from water carried to homes in lead pipes and from lead in paint. So a rational policy would be to give higher priority to abating lead pollution from these sources than to the reduction of lead additives in gasoline. But even on the day the report was issued and before critics had had time to read it, the anti-lead lobby produced a broadsheet denouncing this authorative scientific study as a "coverup" and a "political document." The scientists in the Medical Research Council were labelled "Establishment figures," who had succumbed themselves to pressure from the oil lobby. These critics don't disprove the quantitative data; they don't even dispute them; they simply reject the evidence because it doesn't support the popular prejudice.

So here is another desirable ingredient in the education of the environmental engineer: a critical study of irrationality in public opinion. Fortunately there is plenty of material for study. A lot of work has been done on the mismatch between the statistical assessment of risks and the public perception and evaluation of the same risks. It is common knowledge that people attach more importance to the severity of a hazard than to its frequency of occurrence. The question: "Would you accept a nuclear power system in which there was, on the average, only one major accident every ten years, with only half a million deaths?" would be regarded as a lunatic question. But half a million deaths once a decade is only the extrapolation for ten years of the annual carnage on the roads of America, which is accepted with practically no protest. If you put, in rank order, judgements of the social cost of death you get a surprising result, with nuclear power (which has killed scarcely anybody to date) at the head of the list and alcoholic beverages, smoking, and motor cycling, near the bottom.[6] The problem is made more subtle owing to inconsistencies between the opinions of people about risks and the way they behave. Because infrequent hazards with severe consequences (e.g., air disasters, dam collapses) arouse public disquiet much more than do frequent hazards with less severe consequences (even though on an actuarial basis the resulting risks are the same), public policy decisions to avoid these infrequent hazards may entail great expense. But individuals in their private capacity, whatever fuss they make in public about the dangers from nuclear accidents, air crashes, and the like, behave in a different way when they come to choose insurance premiums for themselves and their families. Their evaluation of the very serious hazard is: "It will never happen to me." They are much more interested in insurance against high-frequency/low-consequence events, such as being burgled or losing their baggage, than they are in insurance against low-frequency/high-consequence events such as floods and earthquakes. Two persons may well agree about the statistical probability of some environmental hazard; what is unpredictable is how they perceive and evaluate the hazard. And this is why the subject of risk-benefit analysis is so important for environmental engineers, political decisions vitally important in your profession are determined largely on this unpredictable factor. Engineers have to accept the unpalatable fact that the subjective assessment of a risk is, for most people, more real than the objective statistical assessment of the risk.

The management of conflict.

Perhaps I should break off for a moment to apologize to you for proposing two extensions to the core-curriculum in the environmental engineer's education: the first, knowledge of how to incorporate unquantifiable values into the decision-equations for environmental policies, taught maybe through a course on environmental ethics. And the second: knowledge on how to reconcile the technologist's judgement about an environmental issue based on hard data (lead levels in air, smoking and lung cancer, probabilities of nuclear accidents) with popular judgement which may have no rational relation to the hard data; taught maybe through a course of risk-benefit analysis. It's reassuring to read, in the position paper by Gloyna and Cooper, that the AAEE are willing to allow an average of 17 per cent of curricular time to be given to humanities and social sciences. That's where this ingredient could be included. But, at risk of choking you with suggestions, I have more to add. For the environmental engineer will inevitably become involved in controversy; he must know something about the management of conflict.

The adversaries in environmental conflicts are often ill-matched. In the British county of Leicestershire at the moment a great controversy is going on between the National Coal Board, which proposes to sink mines in the Vale of Belvoir, and the villagers and farmers who live there. It is a conflict between one good (a massive addition to Britain's energy supplies) and another good (the preservation of a placid stretch of countryside). The Coal Board's case is supported by a brigade of engineers, geologists, economists, and money to pay lawyers. The inhabitants of the Vale are hard put to raise money for the most modest expert advice. Although British law does provide a machinery for public participation, the public are very poorly equipped compared with their opponents. The media describe it as a David-Goliath encounter.

But the significant thing about the original David-Goliath encounter was that David won: and the interesting thing is that in many environmental conflicts the Davids are winning today. Thirty or forty years ago this would have been inconceivable. The public interest lobby was no match for the experts. Today public interest lobbies are so vigorous that you can't propose to build a dam or power plant or extend an airport or bury radioactive waste without being absolutely certain of massive, implacable organized opposition. Advocacy runs roughshod over fact. The conflict becomes emotive and unproductive because the arguments hurled from each side are incommensurable. By what calculus <u>can</u> you measure the benefits of assured energy against the benefits of a serene landscape? Certainly not by the bogus economic trick of "shadow pricing" the landscape. And the politician, mindful that there are more votes in emotion than in logic, is tempted to trade long-term benefits for short-term approval from his constitutents.

This rising tide of public participation, going to the length in Austria and Sweden of national referenda on whether or not to use nuclear power, may be good news for conservationists; but it has a danger, especially for environmental engineers. If participation is wrongly managed, it creates distrust between two categories of people who - in the public interest - ought to have confidence in one another. In a recent symposium on engineering and the environment, the opening speaker talked about the intervention of the "citizen activist" in the USA as "little short of a nightmare." Militant conservationists throw words like 'vandalism' and 'desecration' at engineers who are only doing what society expects of them: directing (in Tregold's words) "the Great Sources of Power in Nature for the Use and Convenience of Man."

Conflicts end in decisions, one way or the other; but a decision is only one of the outcomes and indeed sometimes not the most critical outcome of a conflict. The most critical outcome, if the affair is mismanaged, may be a serious weakening of confidence in the institutions of government. A decision which does not command consent may wither on the vine. What matters just as much is the process by which the decision is reached. The only way to prevent polarization between those whose job is to exploit nature in the public interest and those who, also in the public interest, elect themselves to defend nature, is not to <u>avoid</u> conflict (that would be unrealistic) but to <u>manage</u> conflict. So here is the third extension to the education of the environmental engineer: he needs to have some understanding of the management of conflict.

All pluralistic democracies like our own find themselves in a dilemma over the machinery of public participation. The tradition is that we elect representatives who faithfully look after our interests and that they are advised over technical matters by a staff of faithful public servants, also trying to look after our interests. Confidence in this tradition has been greatly weakened since the war for reasons difficult to diagnose. Active minority groups, claiming to represent public opinion more accurately than their elected representatives or the civil service, now demand to be drawn into the process of decision making. Their influence is magnified by the media because protest and dissent are "news;" consensus and compromise are not "news." So we are at present in a stage of very interesting experimentation. The first steps in public participation were to publish consultative documents and to seek comments on decisions virtually taken already. This sort of cosmetic treatment is nowadays dismissed as "mere tokenism." The next step was to equip the objectors with all the necessary information and even to finance them to prepare their case. This is what the famous Berger Commission did for the enquiry about the Mackenzie River gas pipeline in northern Canada.(7) The Berger Commission adopted a model strategy in other ways, too. It didn't just sit in Ottawa, listening to the sort of people who can come to Ottawa to give evidence. It took to the road - or rather to the Mackenzie Valley itself - and held hearings on Indian reservations, in village halls, tents, and hunting camps. And it created confidence not only in the integrity of the Commission itself, but (a much more important result) in the Canadian <u>process</u> of decision making. One decisive value judgement it made was to show respect for the Indians' concept of land ownership. "The land," said one witness, "belongs not only to the people presently living, but it belongs to past generations and the future generations that are yet to be born."

The San Diego Gas and Electric Company went one step further, when they had to decide on a site for a new power station in southern California. They called a general meeting of the interested parties and got the citizens themselves to set up a committee, which they financed and serviced. Then the company backed out and left the Committee to tour the area and held its own hearings. The Committee came up with a recommendation for a site, which the company adopted.(8)

These are examples of tentative experiments to devise a fresh machinery, suitable for the age of TV documentaries, investigative journalism, phone-ins and citizen forums, to secure public confidence for major decisions which will permanently affect the environment. They are experiments which must not be left to lawyers and politicians: the environmental engineer is a key figure in this developing drama (it <u>is</u> a drama: the future of our environment depends on how the plot develops). Many problems still need to be resolved: Who (for instance) is eligible to participate? How can participants all have equal access to the necessary data? And how can they be educated - without being rejected as propoganda - to understand the data if it is disclosed to them? Environmental engineers can make a great contribution to this process of social innovation, particularly in the art of interpretation of highly technical issues. For an excellent example of this, you do not need to go more than a few blocks from this room. The Ontario Royal Commission of Electric Power Planning published in 1978 a report on nuclear power in Ontario which is (in my view) a masterpiece of popularization without propoganda.[9]

<u>The lesson of the Furbish Lousewort</u>.

Finally I come to what I think may be the most unexpected point in this address, and it's the most difficult point to make. Put bluntly, it is that the Furbish Lousewort - symbolising nature - holds a secret essential to the survival of industrial society, which man has not yet unravelled; and environmental engineers are the sort of people qualified to try to unravel it.

Nature ecosystems such as forests, prairies, and lakes are the products of millennia of evolution. Let me enlarge upon something I wrote last year about this which is relevant to environmental engineers.

Natural systems have their networks of symbiosis, their food chains from plankton to mammals, their recycling plant (aptly summarized by Hamlet: "we fat all creatures else to fat us, and we fat ourselves for maggots"). Manmade ecosystems have similar networks of symbiosis. Recollect what happens when you switch on the light, flush the toilet, put waste in the trash bin, stop to fill up at a gas station, make a phone call. These are signals to fellow members of the ecosystem; after every signal you expect and depend upon a response . . . If the expected responses were to fail widely for all five of these signals, city life would collapse. Already some failures are quite common due to technical faults, human errors, or deliberate anarchy. A power failure in New York; a strike among sewage workers in London; sabotage by a gang of urban guerillas in Belfast - all these have happened; all these are examples of the vulnerability of cities. The ugly fact is that manmade systems lack a fundamental quality found in natural ecological systems: they have none of the built-in stability that preserves or restores equilibrium in forests, lakes, and oceans. The reason for the difference is that in nature, equilibrium has evolved alongside diversity and complexity. Instabilities in natural ecosystems are eliminated by natural selection. In manmade systems we have evolved the diversity and complexity alright: networks of transport, power, sewage disposal, without introducing - indeed without having even invented - the corresponding equalizers to keep man-managed systems in equilibrium. In taking a shortcut to a materialist's Utopia we have failed to include the linchpin of natural ecosystems: their extraordinary resilience.(10)

Last summer I saw in the Canadian Rockies a sober reminder of this. The railroad track through the Rockies is one of the engineering wonders of the world. There is one place where the route has been changed. The old route ascended to a high valley floor, close to some splendid mountain peaks. So a grand hotel was built there; alpine guides were brought out from Switzerland, and the place was developed for tourism. Then, for some reason, a better route for the railroad was found, and the track and the hotel were abandoned. That happened not so many years ago, but the forest has taken charge again. Among the dense undergrowth you can, here and there, see turf-covered remnants of the grand hotel, and there is a narrow bush-covered clearing between the trees where the track ran. In a few decades the pretentious manmade ecosystem has vanished, and the natural ecosystem has colonized it all again.

How is it that the evolution of manmade ecosystems has not produced its own fail-safe stabilizers, such as natural ecosystems possess? I think it may be because the need for stablizers in manmade systems is comparatively recent. In the days before mass aggregation into cities and mass transport and mass communication, <u>space</u> was the great stabilizer. If you lived in a community of, say, five thousand people in the Mid-West, the tensions of Washington, not to say the tensions of Tehran and Calcutta, were too far away to matter. Today, space no longer isolates a community from the perturbations of Western society. The days are over when an industrial dispute in the local mill could be settled by negotiation between employer and employee; a settlement now has to be nationwide, and - as we have learnt in the last ten years - the settlement can be upset and the equilibrium of society tumbled by shock waves generated by a meeting of a dozen Arabs in a parched and desert country, thousands of miles away.

There are other, more subtle, dangers of aggregation in cities. The stability of communities depends upon unwritten social contracts of courtesy and neighborliness. It is difficult to sustain these in the manmade ecosystem of a city, where you eat and drink among strangers, and where the cocktail party with 50 acquaintances has to take the place of a quiet drink with a couple of friends, because it saves time. The urban environment we have created makes it more and more difficult for people to be concerned with one another and equally difficult for them to get away from one another. There are, in short, <u>social</u> limits to growth, and the dangers of exceeding these limits are, it is my conviction, more ominous than are the well publicized dangers of exceeding material limits.

The remedy pressed upon us by some writers is an atavistic retreat to the simple life. To expect industrial society to undergo what biologists would call dedifferentiation into a "small-is-beautiful" social order is simply not on. There is no retreat from a technological society, and the only way cities are likely to be abolished is by nuclear war. So we are saddled with a daunting problem. How can we build, into rapidly evolving technological ecosystems, components to confer stability, fail-safe systems of the kind which preserve natural ecosystems from extinction? It is, I believe, the top priority problem for our generation. We haven't even designed the components that need to be built in yet, let alone decided how to build them in. It's a problem that needs collaboration with political scientists, social psychologists, and suchlike; but is it not, perhaps, the supreme challenge to environmental engineers? Engineers have created the nuts and bolts of the manmade ecosystem; environmental engineers are very active in protecting the natural environment from overexploitation; should they not take on the task of stabilizing the human ecosystem itself?

You may not ever travel to Maine to see the Furbish Lousewort. But the weeds in any patch of natural vegetation issue the same challenge. We have survived, say the weeds, since the Cretaceous. Man is a mere novice in evolution compared with us. He hasn't yet learnt the secret of the weeds: how to create fail-safe communities.

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BANQUET ADDRESS

ENVIRONMENTAL ENGINEERING - A DISTINCT DISCIPLINE?

by

GERARD A. ROHLICH

When Jim Patterson invited me to speak at this conference, he suggested the title above, but assured me that he would welcome any revisions that I wished to make. I found his suggested title interesting, and in fact looked forward to the opportunity to express my personal opinions on the subject.

Subsequently I received, as you all have, the four position papers which present the focal issues of the conference, and which (not to my surprise) delineate substantively many of the thoughts that I had hoped to incorporate in my presentation. Then this morning the excellent papers given by Lord Ashby, and Professors Stumm and Kayser covered not only the additional thoughts that I had, but many more, and were presented much more eloquently than I could hope to do. All of which makes me feel somewhat like the Ph.D. student who was prepared to defend his dissertation but was plunged into despair as his major professor opened the examination with the statement: "I have read your dissertation. It contains many good things and many new things - - - unfortunately, the good things are not new, and the new things are not good."

Nonetheless, the time-honored tradition of post-prandial speechmaking is to be fulfilled; and perhaps a few recollections and random thoughts may add in some small way to our discussions.

To respond to the question posed in the title, it may be of interest to consider environmental engineering from a historic perspective, assess where we are at present, and speculate on where we are going.

Historical Perspective

Although the past decade has been one of unprecedented activity directed toward our concern for the quality of our environment, a superficial look at history shows that this concern, although intensified, is not new.

It is not the intent of my remarks to provide a chronology of the lessons of history and the findings of archaeologists which provide concrete evidence that at least 3000 years before the birth of Christ humans were cognizant of the need to maintain a liveable environment. We can assume that the origins of what we now call environmental engineering are "lost in the mists of antiquity."

To fulfill the role of environmental engineering in our society one faces the dilemma of having breadth as well as depth in a wide range of subjects including climatic, biologic, chemical, and physical sciences, and the complex of social, economic, political, and cultural impacts resulting from the engineering and technological applications required to analyze, design, and implement the central measures directed toward the solution of environmental problems.

Reginald Reynolds[1] in his book "Cleanliness and Godliness" discusses the problem of sanitation and the "magnitude of the subject" as follows:

> "Whoever, indeed, would study this subject with a knowledge worthy of its magnitude must consider it from --- many angles and with --- a wealth of learning. Sanitation has its history, its archaeology, its literature and its science. Most religions concern themselves with it, sociology includes it within its sphere, and its study is imperative to social ethics. Some knowledge of psychology is necessary to understand its development and retardation, an aesthetic sense is required for its full appreciation, economics determine, to a large degree, its growth and extent, while the ultimate disposal of sewage must be viewed in the light of biology."

In a somewhat more narrow sense, but nevertheless indicative of the complexity of our field, the late Professor E. B. Phelps[2] in the preface to his classical book on Stream Sanitation, written in 1944, stated:

> "While serving as an expert witness at one time in a stream pollution case in which all the opposing experts were college professors, I was questioned at some length during cross examination concerning what counsel termed my "chair" -- Sanitary Science -- and the scope of my expert qualifications. "Are you a biologist?" I was asked, "a chemist?" "a botanist?" "Does your

knowledge cover the physiology of fish and the geology of this area?" To all of which I had to reply in the affirmative, with qualifications, for my testimony had, in fact, trespassed upon all these "fields" of science. When opportunity offered I interrupted with, "Perhaps I can save time and trouble if I state that my field is that of potomology. Its study involves all these things you have mentioned and many others, in none of which does the potomologist qualify as a specialist save in his specialty, the science of rivers."

As early as 1924, Professor Phelps had published a series of lectures under the title of "Principles of Public Health Engineering," which in 1948 he expanded to a two-volume text titled "Public Health Engineering," written primarily for engineers but with an approach through chemistry and the biological sciences and stressed "public health through engineering rather than engineering itself." His assumption was that the engineer knew "how to design and build" and the text was to teach the engineer "what to design and why."(3)

Phelps also justified the need for his text because, as he put it, "the sanitary engineer, through his textbooks and his professional activities, has defined and delimited his field not as the engineering of sanitary science, but as the engineering of water supply and its complement, sewage disposal."

We are aware that the development of environmental engineering has relied heavily on the efforts of those in disciplines other than engineering. An early pioneer of Public Health and a strong advocate of sanitary engineering was William Thompson Sedgwick. Sedgwick was appointed Assistant Professor of Biology at the Massachusetts Institute of Technology in 1883 by the new president of the Institute, Francis Walker. The new Professor, then 28 years old, had been an undergraduate student of Walker's at Yale, and had just been granted a Ph.D. in Biology from Johns Hopkins. His first important research contribution at MIT was a study of the dangers of gas poisoning. In this work, he collaborated with Willian Ripley Nichols, Professor of Chemistry at the Institute. Nichols had just published his book on "Water Supply" considered mainly from a chemical and sanitary standpoint, but which contains many basic engineering principles relating to sources of supply and treatment by sedimentation, aeration, and filtration.

In 1889 Sedgwick established at the Institute the course in sanitary engineering. A year earlier he had played an important role in the reorganization of the Massachusetts State Board of Health, and in the establishment of the Lawrence Experiment Station. Although officially biologist to the station, Sedgwick was instrumental in the formation of its policies and in the promotion of legislation empowering the State Board of Health to have "supervision . . . and authority to make rules and regulations for the purpose of preventing pollution and securing sanitary protection of streams and other water sources for water supply."

Further recognition of the growing profession of sanitary engineering was the establishment of a sanitary engineering section in the American Public Health Association in 1911. Thus this organization largely comprised of members of the medical profession acknowledged the importance of the engineer engaged in environmental problems.

But it was not only chemists, biologists, and medical personnel who gave support to the engineer. What is considered by many to be the most important piece of work dealing with the human urban environment was prepared by a lawyer more than a century ago.

On the 9th of July 1842,[4] (which incidentally was noted as a summer of social protest), Edwin Chadwick, Secretary to the Poor Law Commission in Great Britain, presented his "Report on the Sanitary Condition of the Labouring Population of Great Britain" to the House of Lords. The report had been three years in preparation, and although it drew information and statistics from many sources, it was in large part an individual effort by Chadwick.

Chadwick as a civil-servant lawyer had been working in this area for some years, but it wasn't until this report of 1842 that action in the Public Health Movement took place, leading to the Public Health Act of 1848. Time does not permit discussing the many details of Chadwick's report, but it is of interest to note, as pointed out by Flinn[4], the greater part of the report was devoted to establishing "four major axioms."

1. The first section (half of the report) established the factual basis showing the correlation between "insanitation, defective drainage, inadequate water supply, and overcrowded housing -- with disease, high mortality rates, and low expectation of life."

2. The second section was devoted to the economic cost of ill health.

3. The third section dealt with the "social cost of squalor," and

4. The fourth point was concerned with administration in which Chadwick discussed the "inherent inefficiency of existing legal and administrative machinery, in which he argued that the "only hope of sanitary improvement lay in radical administrative departures" which would call for new institutional arrangements. Quite clearly Chadwick was "conscious that . . . centralization would be resisted with all the vigour and fanaticism which landowners, commissioners of sewers and police in several hundred boroughs, vestries, and privately-owned water companies, could muster."

It is obvious that today we are, in many respects, attempting to echo Chadwicks's axioms, first in detailing the factual parts of the problem, then discussing the economic and social costs, and finally seeking legal and institutional arrangements to administer corrective measures.

It is quite clear to this audience that in these few fragments of historical note many of those who have made major contributions to our profession have not received the recognition they deserve. To attempt to name all those who have enhanced the stature of environmental engineering would again undoubtedly result in omissions which some would think unforgiveable. The great names of the latter part of the last century and the early years of this century include workers from a wide variety of disciplines and professions including physicians, chemists, biologists, lawyers, and economists, as well as engineers. In the environmental field this will always be true because by definition the word environmental is all encompassing.

I should mention, in passing, that a major step in giving prominence to our profession was a name change in an early journal in our field. This journal was first published in 1877 under the title "The Plumber and the Sanitary Engineer." It is of interest to note that first billing went to the plumbers, but in 1880 the title was changed to "The Sanitary Engineer."

But we must also pay tribute to three great men, of more recent times, who through dedication and leadership in education and research have contributed immeasurably to the stature of our profession, the late Professors Gordon M. Fair of Harvard & Thomas R. Camp of MIT; and Professor Abel Wolman of Johns Hopkins, who at age 88 is still a keen and active worker unselfishly dedicated to the advancement of environmental engineering.

As you well know the first conference on Graduate Education of Sanitary Engineers sponsored by the American Sanitary Engineering Intersociety Board was held at Harvard University in June 1960. Among the specific recommendations of the conference was the consensus that the program areas should have a common core of chemistry, microbiology, radiological hygiene, statistics, and epidemiology, and that more emphasis should be placed on subjects in public administration, political science, planning, and economics.

Today, on the twentieth anniversary of the Harvard Conference we continue to assess our educational programs in recognition of the fact as stated in the Gloyna-Cooper paper that "the cornerstone of any profession is a professional education." I hope that we will continue to express our differences in opinions as to the elements of program needs in professional education. There will always be room for innovation, and we must avoid the danger of getting into a "fur-lined rut" of rigidly fixed programs that may give the impression of a smooth and easy pathway, but lack the stimulation to generate new concepts and approaches to achieve the diversity of programs and excellence as set forth in the position papers of McCarty and O'Melia, Okun and Busch, and Aulenbach and Brezonik.

An understanding of the changing nature of environmental engineering and the educational programs needed to cope with such changes has never lacked for recognition by the leaders in our profession.

To provide a forum for discussion of these needs, a small group met in 1963 in a "smoke filled room" in a hotel in Chicago to organize the American Association of Professors in Sanitary Engineering. The name of the organization was worded so as not to be restricted to sanitary engineers, but could accommodate those in disciplines other than engineering by use of the wording "Professors <u>in</u> Sanitary Engineering."

At the time of the organization of the Association the group also recognized the growing importance of the role of the Federal Government in regulation of the environment and saw the Association as a vehicle for providing input from educators to the development and structure of the federal programs, particularly in the water and wastewater areas.

To return to the question in the title of these remarks --- "A Distinct Discipline." If we accept Webster's definition of distinct as "distinguished from others" we would probably agree that our profession is a distinct one. It may be that some would find it more difficult to rationalize that environmental engineering is a discipline when we continually argue that an interdisciplinary approach is needed in research and planning for environmental quality, and that essentially every discipline is involved in this kind of activity. Again relying on Webster's definition that discipline is "a field of study" we can probably agree that our field is a discipline, albeit a broad and complex one and that our approach to justifying our position should parallel that of Professor Phelps' response regarding the science of rivers as quoted earlier in this paper. As Aldo Leopold, pioneer in conservation, stated, "The outstanding discovery of the twentieth century is not television, or radio, but rather an awareness of the complexity of the land organism;" and he points out that "by land is meant all of the things on, over, or in the earth."(6) But engineers have never been dismayed by complexity and in our application of the physical, biological, and social sciences to the solution of environmental problems we have already made substantial progress.

This conference, as the three that preceded it, continues to give direction to the educational background which provides the foundation for the practice of our profession. In the next days of the conference we hope to see the direction more clearly. It will be well for us to heed the words of Socrates, "To a man who knows not which port he is headed for, there is no favorable wind."

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<u>STATUS REPORTS</u>

ENVIRONMENTAL ENGINEERING EDUCATION

- PROGRAMS, DEGREES AND FACULTY
- STUDENT ENROLLMENT TRENDS AND FIRST EMPLOYMENT
- MANPOWER NEEDS IN ENVIRONMENTAL ENGINEERING
- FUNDING FOR GRADUATE STUDENT SUPPORT

PROGRAMS, DEGREES AND FACULTY

ROGER A. MINEAR

Department of Civil Engineering
University of Tennessee

The purpose of this report is to present a collection of descriptors that can be used to represent the current status of the Environmental Engineering programs within the countries of Canada and the United States. The principal vehicle for this report is the collection of graduate registries and other AEEP survey information of similar form. The 1980 data presented in this report reflects an increase in available data over that presented orally at the Toronto meeting. The current statistics have come from the program descriptions submitted by 89 Canadian and U.S. programs.

While the present registry information request (as with the past efforts) has been directed at the assembly of information regarding graduate programs in Environmental Engineering, undergraduate education in Environmental Engineering has undergone significant change in the seven years since the last Education Conference. Course offerings in the Environmental Engineering areas to undergraduate students in Civil Engineering have expanded greatly and encompass more than traditional sanitary engineering courses. Curriculum destructuring has resulted in greater selection for undergraduate students in general, but many schools have turned to more formalized recognition of undergraduate environmental engineering education.

This activity is reflected in a May, 1980, article in Environmental Science and Technology by J. W. Patterson (Environmental Engineering Education: Academia and an Evolving Profession, ES&T 14, 524-532, 1980). Citing earlier reports by himself and others, a listing of 27 schools offering either a baccalaureate major or a baccalaureate degree program is presented. Of these 27 schools, 14 are identified as awarding a specific B.S. in Environmental Engineering. (See Table 1.) In addition to this listing, there are other schools, for example, the University of Tennessee, where a formal minor or option is available in Environmental Engineering, so I suspect this list is not comprehensive.

TABLE 1. Institutions offering baccalaureate major or baccalaureate degree program in environmental engineering

[a]	University of California-Santa Barbara
[a]	California Polytechnic State University-San Luis Obispo
	Clemson University
	Dartmouth University
	Duke University
[a]	University of Florida
	Florida Institute of Technology-Melbourne
[a]	Florida Technological University-Orlando
[a]	Humboldt State University
	University of Illinois
[a]	Marquette University
[a]	University of Michigan
	Michigan Technological University
	University of Missouri-Rolla
[a]	Montana College of Mineral Science and Technology
	Ohio State University
[a]	Pennsylvania State University
[a]	Purdue University
[a]	Rensselaer Polytechnic Institute
[a]	Rice University
[a]	Southern Illinois University
[a]	Syracuse University
[a]	Vanderbilt University
	University of Vermont
	Virginia Polytechnic Institute and State University
	University of Washington-Seattle
	Worcester Polytechnic Institute

Sources: "Baccalaureate Programs in Environmental Engineering," J. W. Patterson and J. W. Male, J. Eng. Educ. ASEE 68:4, 1978. "Undergraduate Education in Environmental Engineering," D. Aulenbach, Clearwaters, Jour. NYWPCF, December 1979.

[a] Institution awards B.S. in environmental engineering.

Not all of the schools listed in Table 1 are represented in the forthcoming statistics for one of two reasons, (1) they did not have graduate programs or (2) they have yet to submit their program descriptions. In the latter case, a number of programs have simply declined to participate. However, a representative cross section of educational staff at both the graduate and undergraduate environmental engineering degree levels are contained in the data supplied for the AEEP graduate registry.

GRADUATE PROGRAMS IN ENVIRONMENTAL ENGINEERING

Number of Graduate Programs. Table 2 contains a listing of those 89 programs represented in the 1980 statistics. Typically, but not exclusively, these programs are associated with Civil Engineering departments. Some programs are separate entities with or without associated undergraduate programs. A few are contained in Public Health programs/schools, and a few are associated with Chemical Engineering departments.

In addition to these programs, there are known to be programs of varying magnitude and activity in at least 34 other schools (listed in Table 3). Thus there are at least 123 known Environmental Engineering or closely associated programs in the US and Canada. The data presented represent just under 72 per cent of these programs. There may be another 10 or so programs that have an engineering component or a strongly related, quantitative, environmental science focus that could be included in the total. Because the previous graduate program registers contain no information on the total number of graduate programs in Environmental (Sanitary) Engineering, the 1980 statistics cannot serve as basis for growth in number of programs.

TABLE 2. Programs from Which the 1980 Statistics Have Been Generated

Auburn University	University of New Hampshire
University of Arizona	Clarkson College
University of Arkansas	Cornell University-CE
University of California-Berkeley	Cornell University-Ag. E.
University of California-Davis	Rensselaer Polytechnic Institute
University of California-Los Angeles	Polytechnic Institute of New York
Sacramento State University	Manhattan College
University of Southern California	Syracuse University
Stanford University	University of North Carolina
California Institute of Technology	North Carolina State University
California Polytechnic-San Luis Obispo	Duke University
University of Colorado	University of Cincinnati
Colorado State University	Ohio State University
Howard University	Case-Western Reserve University
George Washington University	Akron State University
University of Florida	University of Oklahoma
University of Central Florida	Oklahoma State University
University of Miami	Oregon State University
Georgia Technological University	University of Pittsburgh
University of Hawaii-Manoa	Pennsylvania State University
University of Illinois	Carnegie-Mellon University
Illinois Institute of Technology	Leheigh University
Northwestern University	Villanova University
University of Notre Dame	Drexel University
Purdue University	University of Rhode Island
Indiana University	Clemson University
University of Iowa	University of South Carolina
Iowa State University	South Dakota School of Mines
University of Kansas	University of Tennessee
Kansas State University	Vanderbilt University
University of Maine	University of Texas-Austin
University of Maryland	Texas A&M University
Johns Hopkins University-Env. Eng.	Rice University
Johns Hopkins University-Pub. Health	University of Houston
University of Massachusetts	Brigham Young University
Massachusetts Institute of Technology	Utah State University
Tufts University	Virginia Polytechnic University
University of Michigan	University of Washington
Michigan State University	Washington State University
Michigan Technological University	University of West Virginia
Wayne State University	University of Wisconsin-Madison
University of Minnesota	Marquette University
University of Missouri-Columbia	University Of British Columbia
University of Missouri-Rolla	University of Toronto
Montana State University	

TABLE 3. Schools with Known Environmental Engineering Programs, not Represented in the Statistics Presented

University of Alabama
University of Alaska
San Jose State University
University of California-Fresno
University of California-Irvine
University of Connecticut
University of Delaware
University of Idaho
Southern Illinois University
University of Kentucky
University of Louisville
Louisiana State University
Tulane University
Harvard University
Northeastern University
Mississippi State University
University of Nebraska
Rutgers University
New Mexico State University
State University of New York at Buffalo
North Dakota State University
Bucknell University
Tennessee Technological University
Memphis State University
Texas Technological University
University of Utah
University of Vermont
Old Dominion University
University of Virginia
University of Wisconsin-Milwaukee
University of Wyoming
University of Alberta
McMaster University
University of Montreal

Degrees Offered. The graduate degrees offered in Environmental Engineering represent an array of degree titles and requirements. Because of variations in reporting degrees and associated requirements, delineating the various degrees according to a prescribed curriculum, baccalaureate degree requirements, and associated entry prerequisites was not possible. While more than 80 per cent of the schools reporting offered a doctorate degree, the title of the degree was variable as evidenced by the listing of Table 4. While the degrees total to 85, this does not mean that 85 schools offered a doctorate degree since in many cases, more than one doctorate degree was offered. Furthermore, while the Ph.D. was unspecified in several instances, the degree was offered in other than a Civil Engineering department and thus would likely reflect this on the diploma. What also is not clear, is whether or not the specification of Environmental Engineering (or other indication) contained in the registry entry is actually honored by the particular university's graduate school since the Ph.D. is strictly a graduate school degree.

On a few occasions, something other than a doctorate or a master's degree was available (e.g., Engineer).

TABLE 4. Listing of Doctoral Degrees Offered

PH.D. UNSPECIFIED	62
PH.D. ENVIRONMENTAL ENGINEERING	15
DOCTOR OF ENVIRONMENTAL	2
DOCTOR OF PUBLIC HEALTH	1
DOCTOR OF SCIENCE	2
DOCTOR OF ENGINEERING	2
PH.D. ENVIRONMENTAL SCIENCE	1

Many graduate programs offer a selection of master's degrees which have varying curriculum requirements, thesis-nonthesis options, undergraduate degree requirements, and entrance prerequisites, not all of which were clearly detailed. Two observations can be made from the array of degree titles and the accompanying information. First, there are numerous titles applied to master's degrees offered in Environmental Engineering programs. Table 5 presents a listing of titles presented in program descriptions. There are clearly some favorites but consistency is absent.

The second observation is that a particular degree title does not have consistent academic requirements associated with it. A partial qualification could be applied to the MSCE degree in that typically, an accredited BSCE degree is required before the MSCE can be obtained. Even this degree is variable in that the submission of a research thesis is not fixed.

Faculty Characteristics. A number of faculty characteristics have been assembled from the current information submitted for the latest Graduate Registry and from the 3 previous registries to characterize the current faculty makeup in Environmental Engineering Education and to contrast these characteristics with past data.

TABLE 5. Listing of Master's Degrees Offered

Master of Science	33
M.S. Civil Engineering	27
Master of Engineering	18
M.S. Environmental Engineering	25
M.S. Environmental Science	6
M.S. Sanitary Engineering	5
M.S. Engineering	4
Master of Civil Engineering	3
Master of Environmental Science	4
Master of Environmental Engineering	1
M.S. Environmental Health	2
M.S. Environmental Health Engineering	2
Master of Engineering, Environmental Engineering	4
M.S.E. Environmental Engineering	1
Master Health Science	1
M.S. Environmental Health Science	2
Master Applied Science	2
Master of Physical Science	1
M.S. Water Resources	1
M.S. Pollution Control	1
M.E. Pollution Control	1
M.S. Environmental Systems Management	1

Those characteristics presented are:

- Average Full Time Faculty
- % of Faculty with a Doctorate
- % of Faculty that are Registered P.E.'s
- % of Faculty belonging to AEEP (1974, 1980)
- % of Faculty that are AAEE Diplomates
- Number of faculty per program
  - average value
  - distribution of program sizes (1974, 1980)
- Distribution of Faculty by Rank

Table 6 presents a summary of much of these data for the years 1965, 1969, 1974, and 1980. If these data are indeed representative for each of the years and the differences are statistically valid (no statistical tests have been made), the following observations are in order.

(1) The average faculty per program peaked in the mid 1970's and is experiencing a decline. Over the years, the average number of faculty has held between 5 and 6 (or slightly above).

Data for 1974 and 1980 are presented in Figures 1 and 2 which provide the distribution of programs by the number of faculty. A few large programs tend to skew the distribution but 4 to 5 faculty programs are dominant in both years.

TABLE 6. Environmental Engineering Graduate Program Faculty Characteristics

Characteristic	Year 1965	1969	1974	1980
Avg. Full Time Faculty/School	5.0	5.0	6.5	5.9
Per Cent of Faculty Holding a Doctorate Degree	76	Not Available	87.4	97.5
Per Cent of Faculty Holding Professorial Engineering Registration	43.0	42.7	50.1	52.3
Per Cent of Faculty that are AEEP Members	Not Available	Not Available	23.7	29.2
Per Cent of Faculty that are AAEE Diplomates	12	8.5	10.2	12.0

(2) The move to an extremely high percentage of faculty with earned doctorate degrees is evident over the 15-year interval. This may reflect major university attitudes as a whole as well as those of the Environmental Engineering profession.

(3) There is an increase in per cent of faculty holding professional engineering registration but this is not as dramatic as the increase in doctorate degree holders.

(4) In contrast with 1974, an increase in AEEP membership is indicated but clearly the organization represents only a modest fraction of educators in the field.

(5) The per cent of faculty that are AAEE Diplomates has returned to the 1965 level, showing an upward trend over the past 10 years (if the differences are in fact real).

FIGURE 1. Distribution of Program Size, 1974 Data

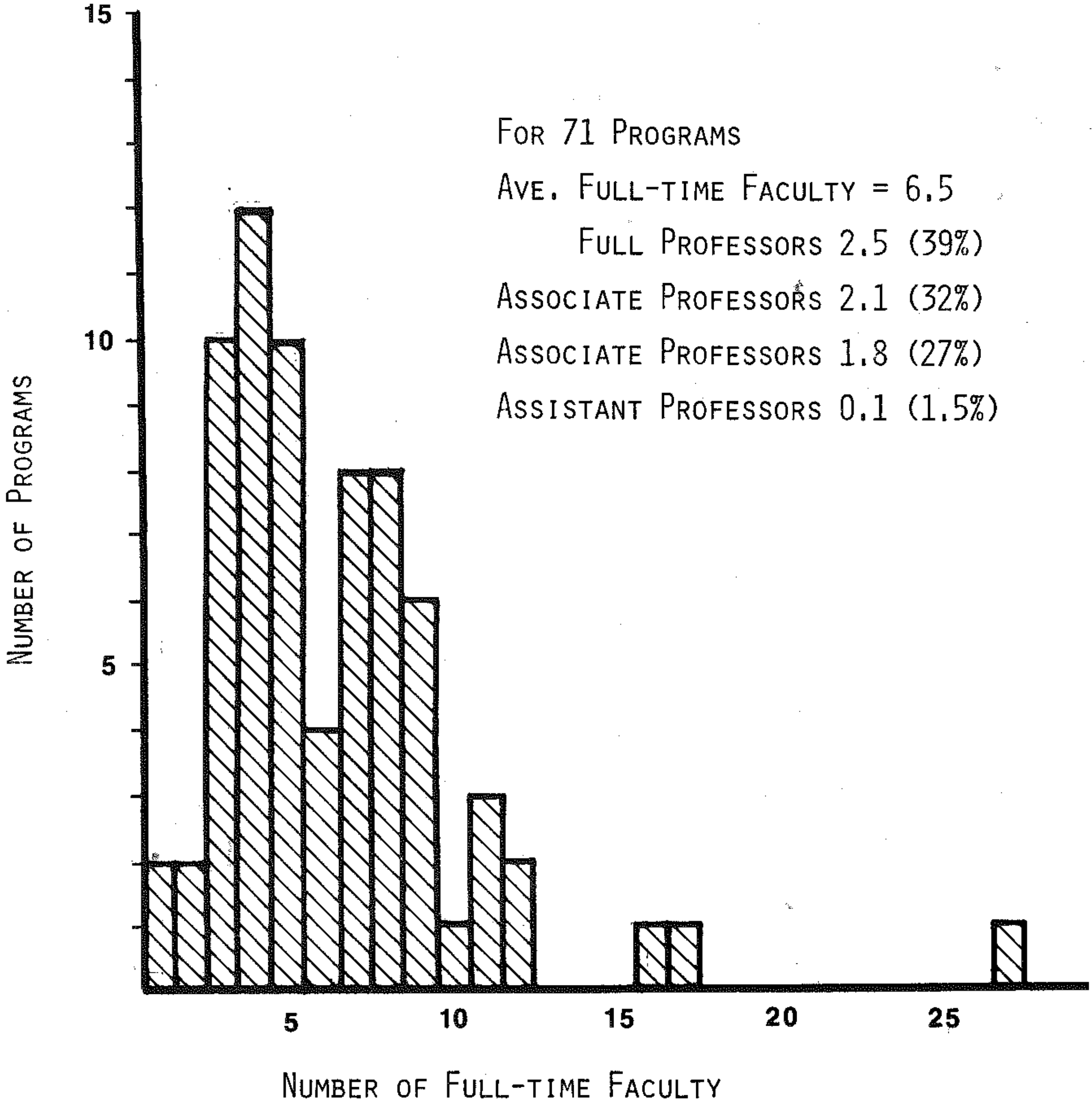


FIGURE 2. Distribution of Program Size, 1980 Data

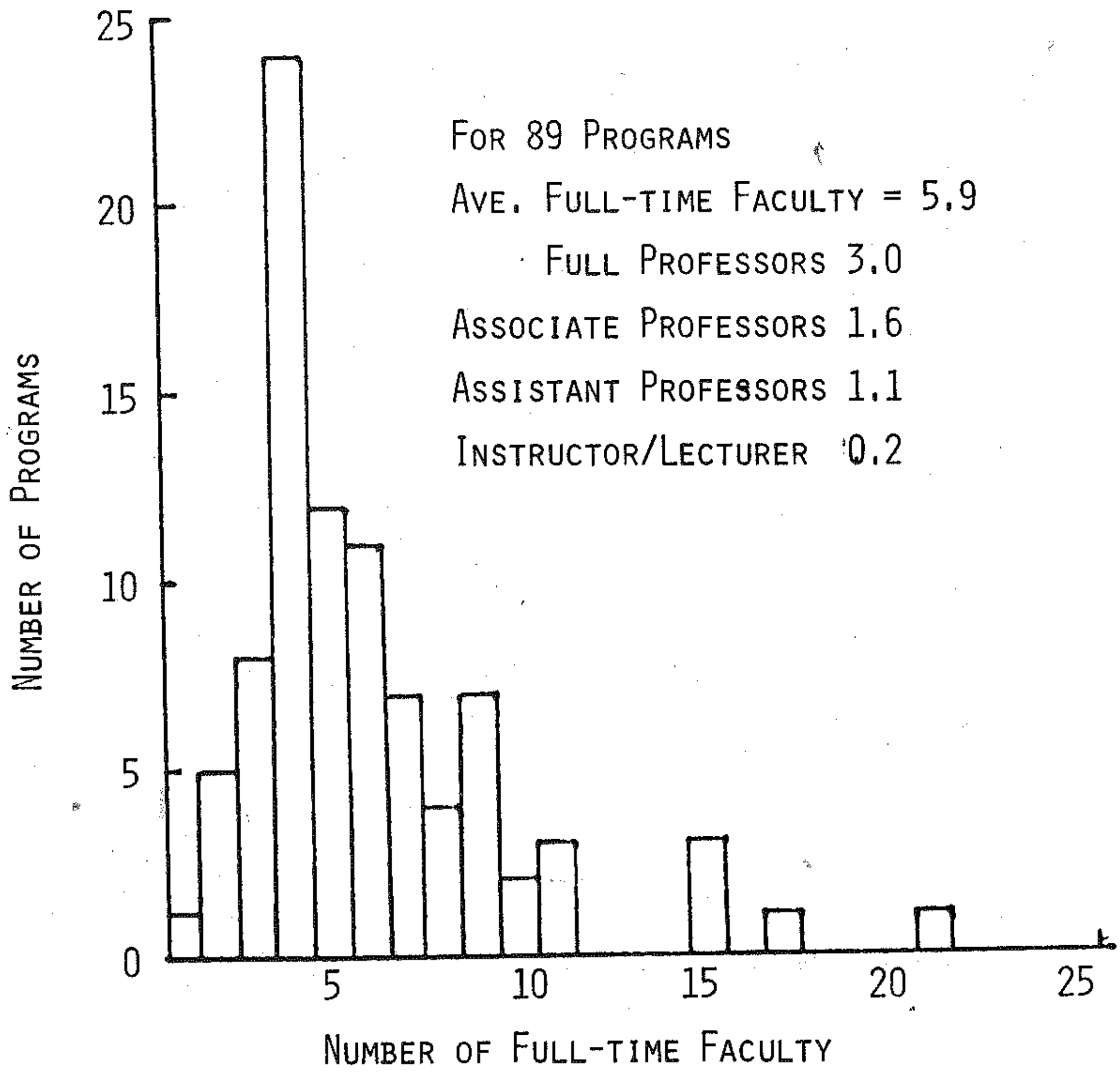
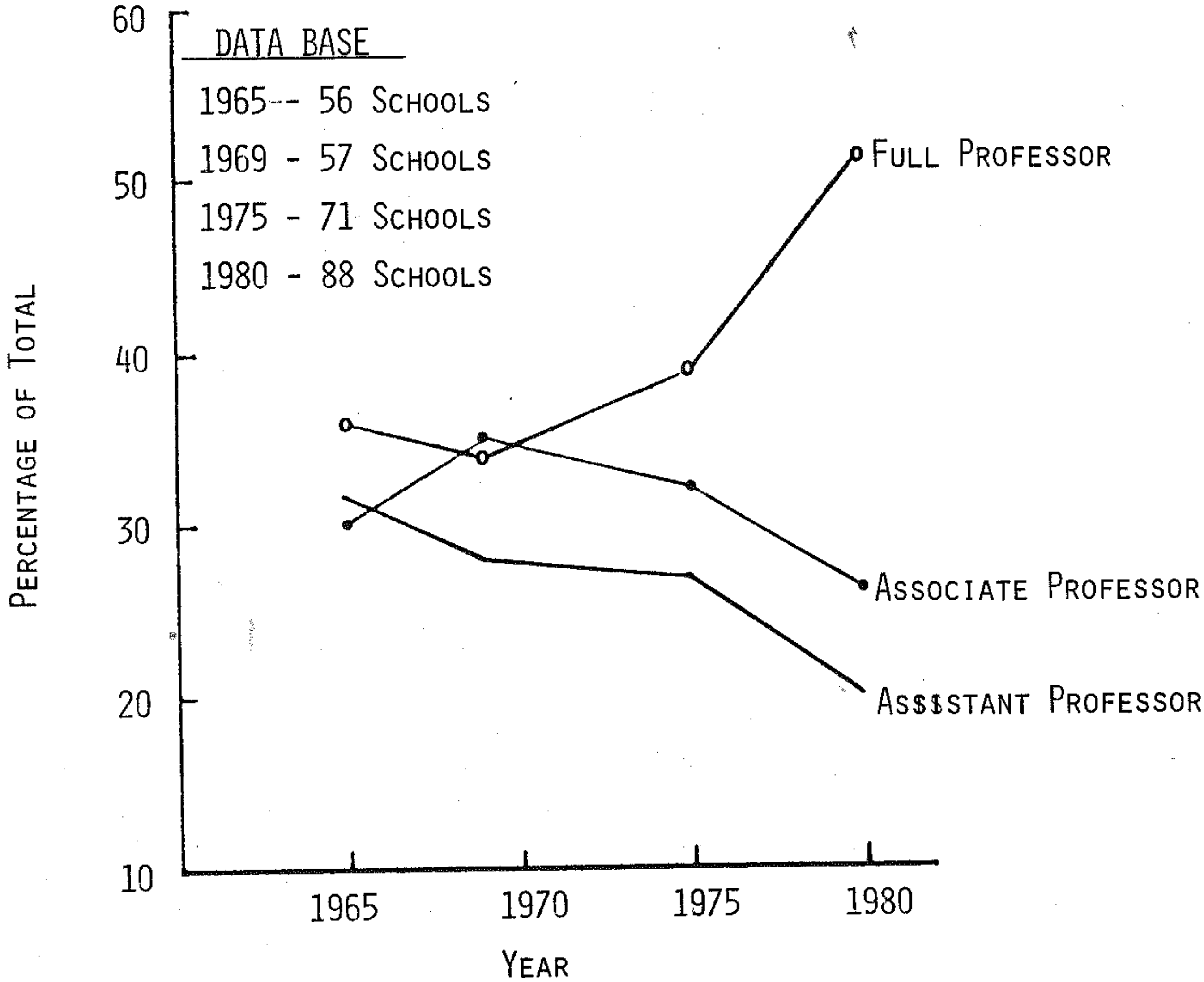


FIGURE 3. Distribution of Faculty Rank



The distribution of faculty by professional rank for each year was determined on a percentage basis for full time faculty. These data are presented in Figure 3. The most dramatic differences of all are demonstrated here. Clearly, the distribution of faculty rank has shifted strongly to the full professor level over the past 10 years. A number of factors for this condition might be conjectured, and more likely a combination of reasons is responsible. On the positive side, we are currently a profession of experienced and, presumably, mature, saged individuals. On the negative side, we would appear to be not attracting new blood into the process stream (or may simply be plugging this entry as we grow older and advance in academic rank in a plug flow sense).

SUMMARY

This report has presented statistics to serve as a part of a characterization of Environmental Engineering Education as it stands today and in contrast to past years. The initial data presented in Toronto have changed little in overall character by the addition of 33 programs to the 1980 data summary. In this light, acquisition of the outstanding program descriptions would likely not change the trends indicated.

These data were intended to serve as a backdrop to the discussion group issues and should also be the basis for further introspection by the profession as a whole and AEEP in particular in the near future.

STUDENT ENROLLMENT TRENDS AND FIRST EMPLOYMENT

P. AARNE VESILIND

Department of Civil Engineering
Duke University

The objective of this paper is to report on the results of the continuing AEEP survey of environmental engineering enrollments, and to introduce the results of a survey on first employment of environmental engineering graduates.

Enrollments

The AEEP has, since 1973, been conducting surveys of students' enrollments in environmental engineering programs. The objective of these studies, carried out as a service to the profession, is to establish a basis for estimating the available manpower in environmental engineering, and to identify areas where technical manpower needs will exceed supply.

Initiated in 1973 by Wesley O. Pipes, who also obtained the data for 1971 and 1972, the surveys have been conducted by:

Wesley O. Pipes (1973)
Paul King (1974)
William Jewell (1975, 1976)
P. Aarne Vesilind (1977, 1978, 1979)

As the survey mechanism and procedure matured, better and more accurate data became available. The voluntary and enthusiastic cooperation of the members of AEEP and others guarantees that the survey continues to serve as a valuable source of pollution control manpower availability. The results of the survey are used by the private sector as well as the federal government for program evaluation and development.

The programs surveyed are all associated with an engineering department or a school of public health which has an environmental engineering division. This does not include programs in environmental studies (science, management, etc.) usually associated with departments of forestry, biology, life sciences, etc.

Because it is nearly impossible to obtain a 100 per cent return on questionnaires, the data must be adjusted in order to be able to make year-to-year comparisons. Two types of adjustments are used:

a) Only those programs reporting each year are counted, thus detecting relative enrollment trends in existing programs.

b) All of the responses are tabulated and multiplied by a factor equal to the number of responses received.

Table 7 represents graduate enrollment (M.S. and Ph.D. students) from 52 programs, all of which responded for the three consecutive years. In these programs, the number of sanitary (water and wastewater) engineering students seems to be holding fairly constant, while the number of students studying other science and engineering disciplines seems to be increasing.

Using the second method of data adjustments, it is possible to estimate long-term trends which reflect the student population in existing programs, as well as the dismantling of old programs or the establishment of new ones. The adjusted data for the last four years is shown in Table 8.

TABLE 7. Graduate Enrollments in 52 Selected Programs

	Fall Semester		
Program	1977	1978	1979
Sanitary Engineering	747	655	696
Other Environmental Sciences and Engineering	439	490	582
Totals	1,186	1,145	1,278

TABLE 8. Environmental Engineering Graduate Student Enrollments

	Fall Semester			
	1976	1977	1978	1979
Total full-time graduate students in environmental sciences and engineering	2,292	2,519	2,479	2,511
Sanitary (water and wastewater) engineering	1,015	1,260	1,467	1,440
Air pollution	173	139	185	157
Solid waste	?	?	15	24
Water resources	496	492	216	239
Environmental sciences and management	1,670	1,342	696	650
Part-time students	1,406	1,359	1,463	905
Number of federal traineeships	244	232	260	200

The data for the year 1976 is unadjusted, and this figure is used as a datum, since the survey in 1976, conducted by William Jewell, resulted in a virtual 100 per cent return rate.

These data are also shown graphically in Figure 4. Following a precipitous drop in enrollments due to the cutback in federal traineeships in 1973-74, the number of students in graduate environmental engineering programs seems to be slowly increasing. Over the past four years, the total graduate student population is steady, but water resources, environmental sciences, and part-time student enrollments have decreased.

The trend in new M.S. students enrolling in environmental engineering curricula is shown in Figure 5. Again, it seems that the number of new students seems to be increasing.

The AEEP survey has not, in the past, been concerned with enrollments in undergraduate environmental engineering programs. Only in the 1976 questionnaire was there a specific request for numbers of students enrolled in

FIGURE 4. Graduate Environmental Science and Engineering Enrollments

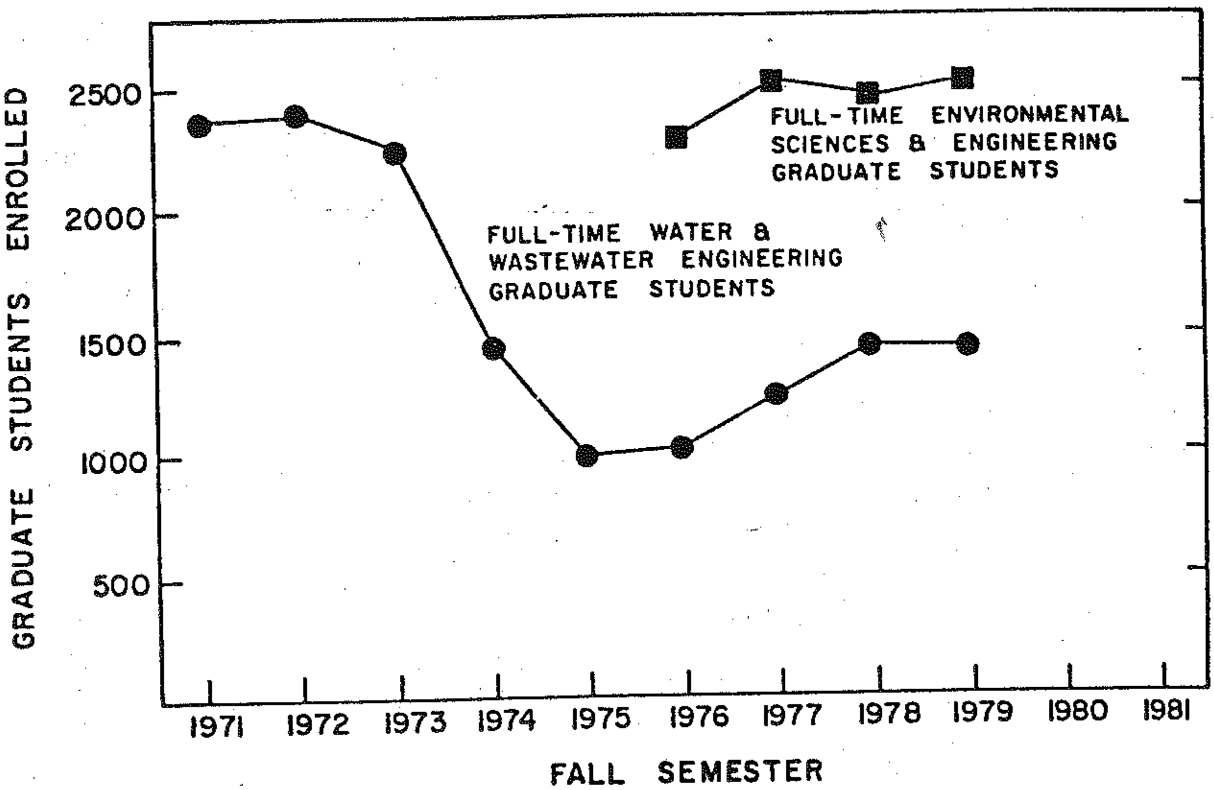
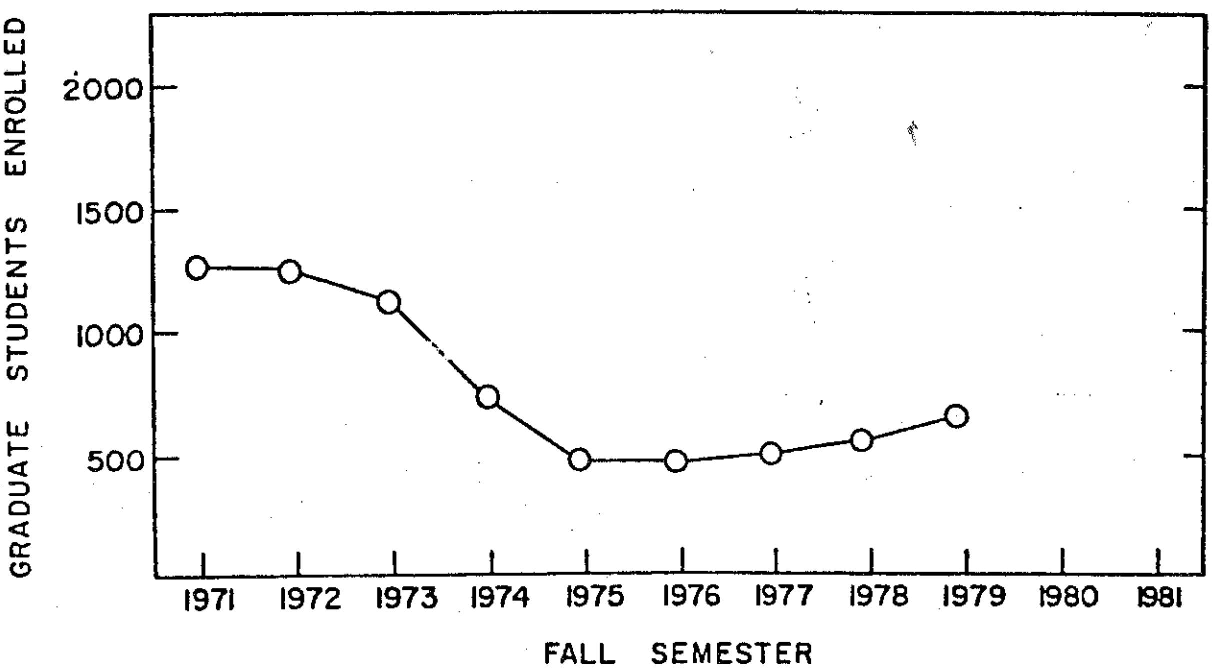


FIGURE 5. New M.S. Students in Environmental Engineering



undergraduate programs. Fortunately, the results of a survey conducted by Patterson and Male can be used to establish historical trends for undergraduates. The students counted in this survey are those identified as being enrolled in an undergraduate environmental engineering program regardless of their class standing.

The data is plotted in Figure 6 and show a steady and smooth growth in the number of undergraduate environmental engineers.

Employment

The AEEP enrollment survey does not ask for information on the place of first employment. In order to obtain the information, a special survey was conducted, using a stratified sample (schools representing a wide range of sizes, geographical locations, etc.). Fourteen questionnaires were mailed, and amazingly, 14 were returned. The data is shown in Table 9.

Using the percentages from the actual data, it is possible to estimate the absolute number of graduates, using again the assumption that there are 111 environmental engineering programs.

Almost 40 per cent of all M.S. graduates enter government employment, whereas about 44 per cent obtain jobs in the private sector. As expected, over half of the Ph.D's enter academic pursuits.

Employment figures for previous years are difficult to obtain. Purdom tabulated some numbers from EPA documents for the graduates during 1971, and these are shown in Table 10, along with the 1979 results. While the government seems to attract an equal percentage in 1971 and 1979, there is a dramatic increase in the number of graduates entering the private sector. This increase seems to be in some substantial part at the expense of further education and academics.

Patterson and Male reported the results of a survey of B.S. environmental engineering graduates. Their data, shown in Table 11, suggests that a much lower fraction of B.S. degree graduates enter government service, while almost a majority (45 per cent) enter the private sector.

FIGURE 6. Undergraduate Environmental Engineering Enrollments

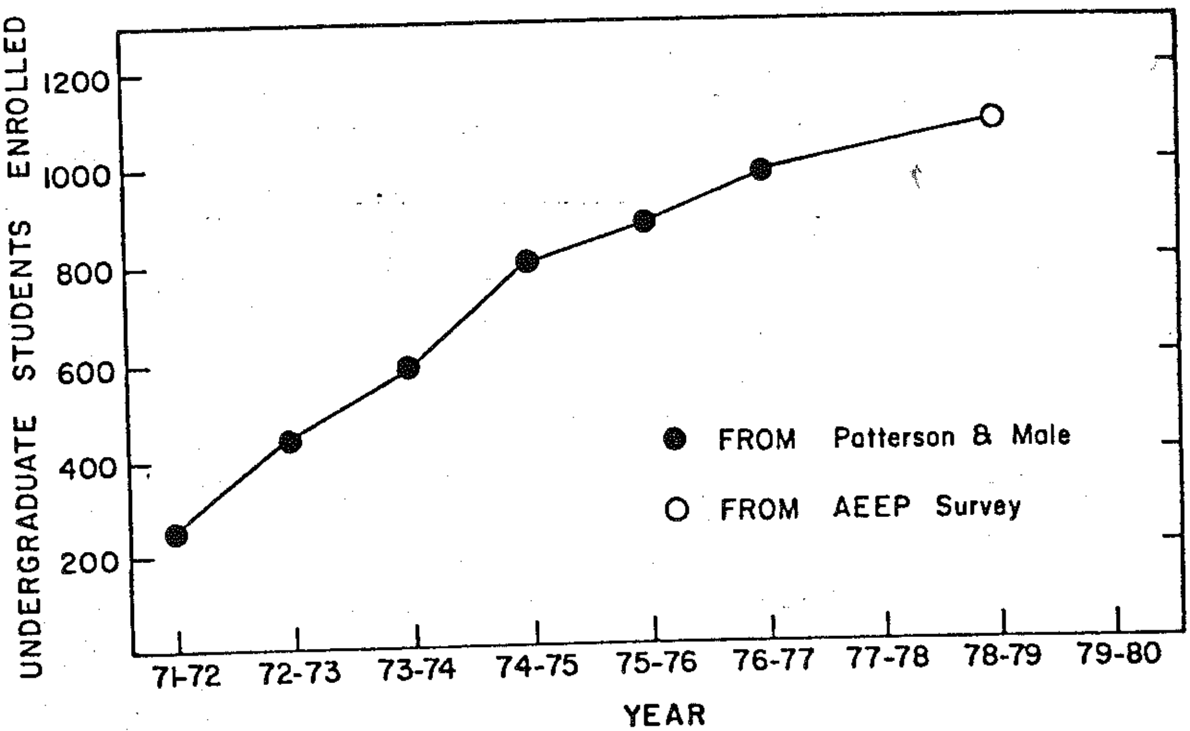


TABLE 9. First Employment of M.S. and Ph.D. Environmental Engineering Graduates

Employment	Number of 1979 graduates														Sample Total	%	TOTAL*
Master of Science																	
Consulting engineers	1	1	5	6	0	13	3	0	5	0	3	0	4	3	44	28	349
Federal government	2	1	2	3	5	5	0	0	0	0	1	1	0	0	20	13	158
State or local government	1	0	12	1	3	8	0	1	6	3	1	1	0	4	41	26	325
Industry	1	0	4	2	3	11	2	0	1	0	0	0	0	2	26	16	206
Continue education	1	0	1	2	3	2	1	0	1	1	0	0	0	0	12	8	95
Other (or unknown)	1	0	0	0	3	10	0	0	0	0	0	0	0	0	14	9	111
															157	100	1244
Ph.D.																	
Consulting engineers	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2	12	16
Federal government	0	0	0	0	0	1	0	0	0	0	0	1	1	0	3	17	24
State or local government	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	8
Industry	0	0	0	0	0	0	0	0	0	0	1	0	1	2	2	12	16
Academics	0	1	2	0	0	3	0	0	0	1	0	0	0	2	9	53	71
															17	100	135

*Total, based on 111 environmental engineering programs

TABLE 10. Comparison of 1970-71* and 1978-79 First Employment by Graduates (MS and Ph.D.) of Environmental Engineering Programs

Employment	1971	1979
Government (all)	34%	37%
Industry and consulting	20%	43%
Academics	15%	5%
Continue education	13%	7%
Other & unknown	18%	8%
	100%	100%

*From EPA annual reports, compiled by P. Walton Purdom, presented at the Third National Environmental Engineering Education Conference, Drexel University, 1973.

TABLE 11. First Employment of Graduate of B.S. Environmental Engineering Programs 1972-1976*

Employment	Number	Per Cent
Consulting engineers	51	19%
Federal government	10	4%
State or local governments	18	6%
Industry	72	26%
Continue education	66	24%
Other (or unknown)	56	21%
	273	100%

*Data from James W. Patterson and James W. Male, "Baccalaureate Programs in Environmental Engineering," Engineering Education, January, 1978.

Conclusions

Enrollment figures present an encouraging picture, both for graduate as well as undergraduate environmental engineering programs. There is some indication, however, that the economic conditions as well as the further cutback in federal traineeships will adversely affect graduate enrollments. Students with M.S. degrees are routinely being offered $22,000 salaries by industry. Federal government salaries are also competitive. It is thus increasingly difficult to convince good students to stay in school, and this factor will no doubt show up in next year's enrollment figures.

The AEEP employment survey asked for an indication of salary ranges received by the graduates. In most cases, this information was not known, and the space was left blank. One respondent, however, volunteered the following:

"I do not have a strong feeling for starting salaries, except to say that I am tempted to enter the job market."

MANPOWER NEEDS IN ENVIRONMENTAL ENGINEERING

DR. EARNEST F. GLOYNA

Dean, College of Engineering
University of Texas

The education of technical personnel, and more particularly specialists such as environmental engineers, requires a long lead-time. In this respect, I am of the opinion that there are insufficiently trained environmental engineers in every major country.

In the US, there exists a serious shortage of expertise in environmental engineering. Furthermore, there exists no meaningful manpower assessment program to examine in detail the situation of future supply and demand of technical manpower and no plan whatsoever for training programs. Governmental actions seem to minimize the role of engineering on one hand, and on the other hand, subscribe to a dream-world of providing instantaneous technological solutions.

The dwindling pool of environmental engineers, who have had some form of academic education, continues to decline. In 1976, there were slightly over one million engineers and scientists actually working. Environmental/sanitary engineers accounted for only 9,424. This relationship should tell us something about the state of affairs as regards to professional utilization. Today the national production of engineers and scientists in the USA, on an annual basis, is:

58,000 engineers
90,000 scientists
862 environmental engineers
(309 B.S.)
(517 M.S.)
(36 Ph.D.)

The magnitude of the manpower challenge can be more specifically exemplified by just looking at the energy-related question. For example, should the USA ever develop a well-designed plan for massive domestic energy resources, there will be an enormous requirement for well-trained environmental personnel. Just to achieve 2.6 million barrels per day of synfuel production in the 1980's will require:

25,000 new engineers
11,000 new scientists

It should be noted that engineers constitute 70 per cent of the technical manpower requirement in energy-related areas.

The international requirements are even more revealing. The Pan American Health Organization estimates that to extend water-supply sanitation coverage to the entire population of Latin America by 1990 will require about 400,000 more workers in this sector. Based on a 3 per cent professional training format, this massive effort will require about 12,000 professionally educated environmental engineers. Obviously, it is not likely that this challenge will be met with overwhelming success.

In the 1980's graduate-level education in the US will be in serious difficulty. Production of MS engineers will, at best, remain steady. The Ph.D. production has been declining since 1972 and will probably continue downward because of governmental neglect. The net productivity of Ph.D.s who have had a background of undergraduate work from an ECPD/ABET level education had dropped to about 1,700 in 1978. During this time in the US foreign students, many not having ECPD/ABET level competency, constitute 35 per cent of the Ph.D.s granted. The number of engineering graduate students failing to meet the design and synthesis component in their educational base is increasing.

Prior to 1977, the Congress mandated the study of manpower for environmental pollution control. This resulted in a 427-page document prepared by the U.S. National Research Council (NRC) in 1977. This conference today could very well utilize some of the statistics, conclusions, and recommendations that were developed in the NRC study. The introduction comments in the NRC study are:

> "Manpower aspects of pollution control are a key factor in carrying out the nation's goals for improving environmental conditions. Shortage

of well-trained and experienced manpower can slow the development of control technologies, affect program administration, cause inefficient control plant operations and process failures, and boost the cost of achieving environmental controls. Numerous complex and interrelated factors are involved in assuring that the supply of and demand for trained and experienced people are well-balanced.

The Environmental Protection Agency (EPA) has responsibilities in this regard that are explicitly called for by existing statutes implicit in the intents, and inherent Agency leadership of these matters, either in meeting defined responsibilities or in seeking clarification of EPA's role."

In 1977 it was not apparent that the production of Masters and Ph.D. people in environmental engineering would decline as rapidly as it has.

The first recommendation proposed by the NRC Committee is as follows:

> "The Committee recommends that Congress clarify its intent for environmental manpower development in training activities in existing legislation and provides EPA with a clear directive concerning its manpower and training authority."
>
> "The importance of manpower needs should be recognized by Congress and the executive and appropriately reflected in the agency's budget. Manpower planning and training should be adequately funded; there should be no diversion of manpower planning funds to other activities."

As the world continues to develop into a technologically oriented environment, technical competence in environmental engineering becomes more apropos. It behooves this group of educators assembled here today to exert its collective influence on quality control, appropriate utilization of environmental expertise, and an international reawakening of the need for competently trained environmental engineers.

FUNDING FOR GRADUATE STUDENT SUPPORT

Stanley L. Klemetson
Associate Professor

and

Gary L. Rogers
Research Associate

Department of Civil Engineering
Colorado State University

During the past ten years there have been significant changes in the method of support for graduate education. The late 1960's and early 1970's were a period of developing national concern for the environment. The public demanded protection of the environment, and the government responded with support for graduate education in environmental education.

In the late 1970's and beginning of the 1980's national concerns have changed. The energy shortages have caused the public to request more energy development with less concern for the environment. The high costs of environmental regulations have turned the public and government policy against many of the earlier environmental concerns. As a result, environmental engineering graduate programs have lost most of the earlier financial support.

The manpower need in environmental engineering is still here and is getting worse. How are we meeting this demand for more graduates? In this paper, a comparison will be made between the earlier report by Kaufman and Middlebrooks (1970) on sanitary engineering education and the results of the current data collected by the authors on the sources of funding for graduate education in environmental engineering.

Sources of Data

The data of ten years ago was summarized by Kaufman and Middlebrooks from the 1969 Register of Sanitary Engineering Education Programs. A total of 45 schools was eligible for inclusion in the reported data on the sources of student support.

During the intervening years several surveys were conducted to determine the trends in the method of support and the number of students enrolled. The latest survey was conducted by Klemetson and Rogers for the AEEP Research Committee. A questionnaire was sent to 104 existing programs, and results were received from 60 of these. These results were not normalized to compare directly to the 1969 data but were converted to percentages to show the trends.

Evaluation of the Data

Many of the students entering graduate programs in the late 1960's did so with the assistance of some type of federal traineeship or grant. As shown in Table 12, during the following ten-year period, the number of environmental engineering programs more than doubled, but the number of those receiving traineeships and fellowships fell by more than half. The number of Ph.D. students receiving any type of traineeship or fellowship dropped to almost nothing.

TABLE 12. Summary of Training Grant and Fellowship Support in Environmental Engineering Programs

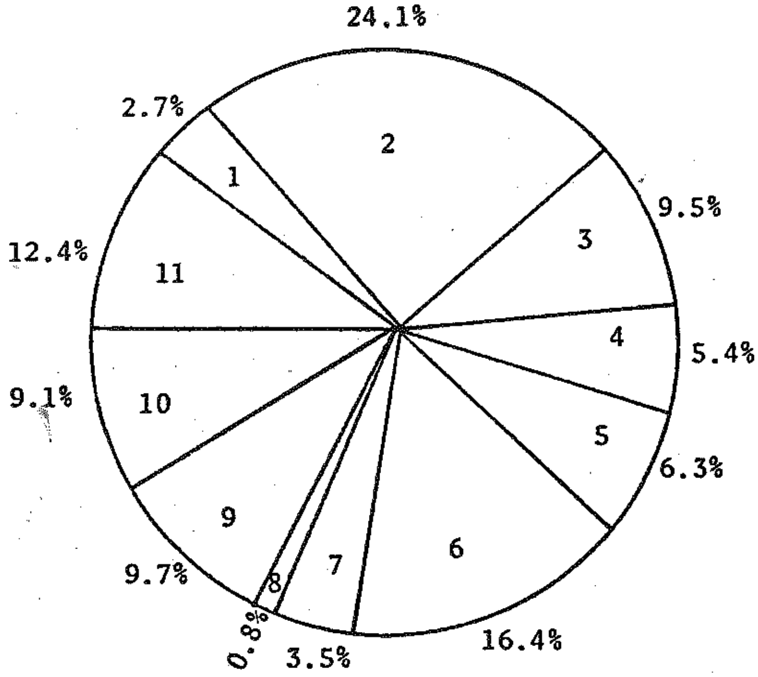
	1969		1979	
Source of Funding	M.S.	Ph.D.	M.S.	Ph.D.
US EPA (water) (FWPCA)	144	44		
Public Health Service	60	43		
National Science Foundation	4	4		
Department of Defense	13	3		
Industry	2	0		
State Agencies	30	7		
Foreign Governments	17	4		
Total Number of Students	270	105	99	5
	45 Schools		60 out of 104 Programs Contacted	

As the various programs started to increase the number of students supported on research projects (Table 13), even with only 60 schools out of the 104 possible reporting in 1979, there was a fourfold increase in the number of students supported by research contracts. The percentage distribution of this funding in 1979 is shown in Figure 7.

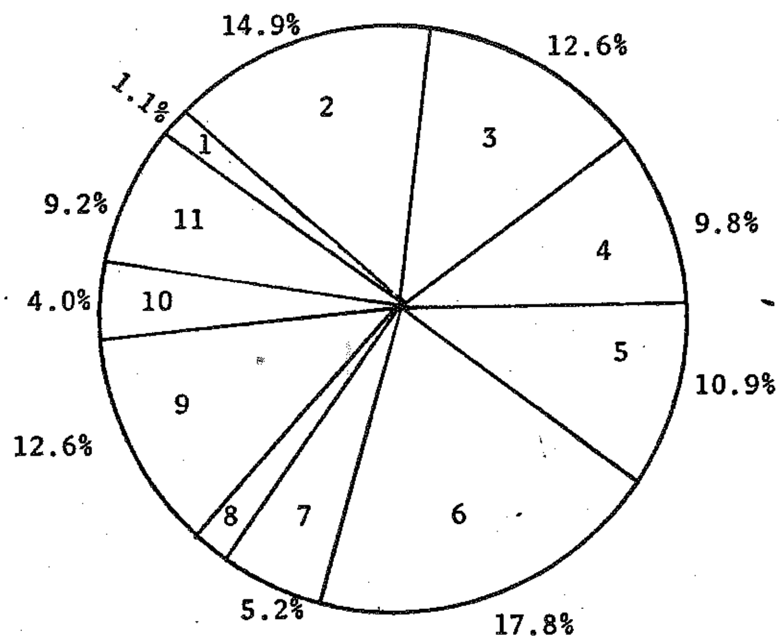
Support for graduate education also comes from three other classes of sources. At the university, some students receive scholarships, graduate teaching assistantships, or graduate research assistantships.

TABLE 13. Summary of Research Support in Environmental Engineering Programs

Source of Funding	1969 M.S.	1969 Ph.D.	1979 M.S.	1979 Ph.D.
US EPA (air)	0	0	33	2
US EPA (water) (FWPCA)	22	19	117	26
Public Health Service	6	4	0	0
Office of Water Research and Technology	33	21	46	22
National Science Foundation	2	1	26	17
Department of Defense	3	1	0	0
Department of Energy	0	0	30.5	19
Other Federal Agencies	17	6	79.5	31
Private Foundations	0	0	17	9
Professional Organizations	0	0	4	3
Industry	7	2	47	22
State Agencies	15	2	44	7
Other (city or regional)	0	0	60.5	16
World Health Organization	11	1	0	0
Total Number of Students	110	57	484.5	174
	45 Schools		60 out of 104 Programs Contacted	



M.S.



Ph.D.

(1) US EPA (air)
(2) US EPA (water)
(3) Office of Water Research and Technology
(4) NSF
(5) DOE
(6) Other Federal Agencies
(7) Private Foundations
(8) Professional Organizations
(9) Industry
(10) State Agencies
(11) Other (city or regional)

FIGURE 7. Comparison of M.S. and Ph.D. Environmental Engineering Students Sources of Research Funding for 1979

While these have increased overall, they are beginning to become more scarce as universities start to tighten their financial belts.

Another class of support is considered as external to the campus. These include training leaves, foreign government, international organizations, and any other type of outside support by which the student is supported while he attends school.

The last class of support is self-support. A few students are able to live off their savings while attending school. A larger number of these must work part-time or full-time while attending school. A significant number of students fall into this category since training grants are no longer readily available.

The distribution of students by numbers by each class of support is shown in Table 14. Since these numbers are not easily correlated with the data collected in 1969, Table 15 presents the data as percentages of total students. The data for 1979 is also presented in a pie diagram in Figure 8.

At the Master's level, those students wishing to study full-time must consider a graduate research assistantship as the most likely form of support since training grants are seldom available. At the Ph.D. level, even more students are involved in research contracts. There has been a very large increase in the number of students which have had to extend their education over a longer period of time because of the need to work full or part-time to support themselves and their families.

Enrollment

Trends in enrollment in environmental engineering have been surveyed for the past ten years.

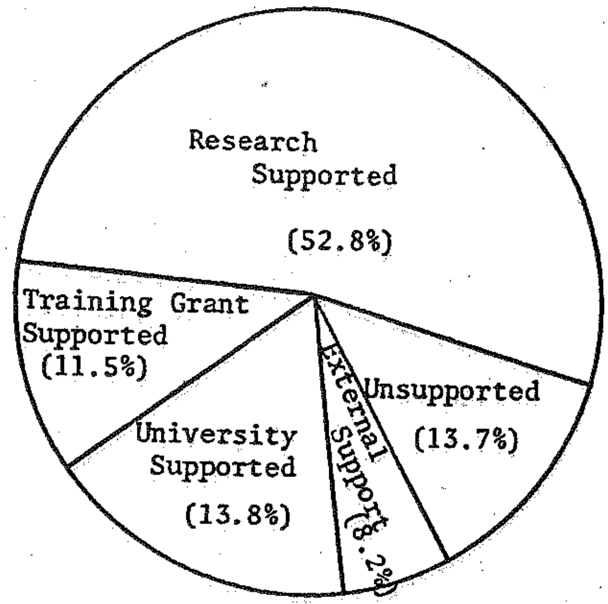
The 1976 survey conducted by William Jewell and Michael Switzenbaum is perhaps the most accurate and dependable since more than 95 per cent of the total students enrolled in environmental engineering were believed to be included in the responses. These surveys have since been conducted by Aarne Vesilind of Duke University. While the response in recent years has never matched the 1976 results, the data has been normalized by a multiplication factor which involves the 1976 response total divided by the response of a given survey (Aarne Vesilind, personal communication).

TABLE 14. Sources of Student Support in Graduate Environmental Engineering Programs by Total Numbers Reported

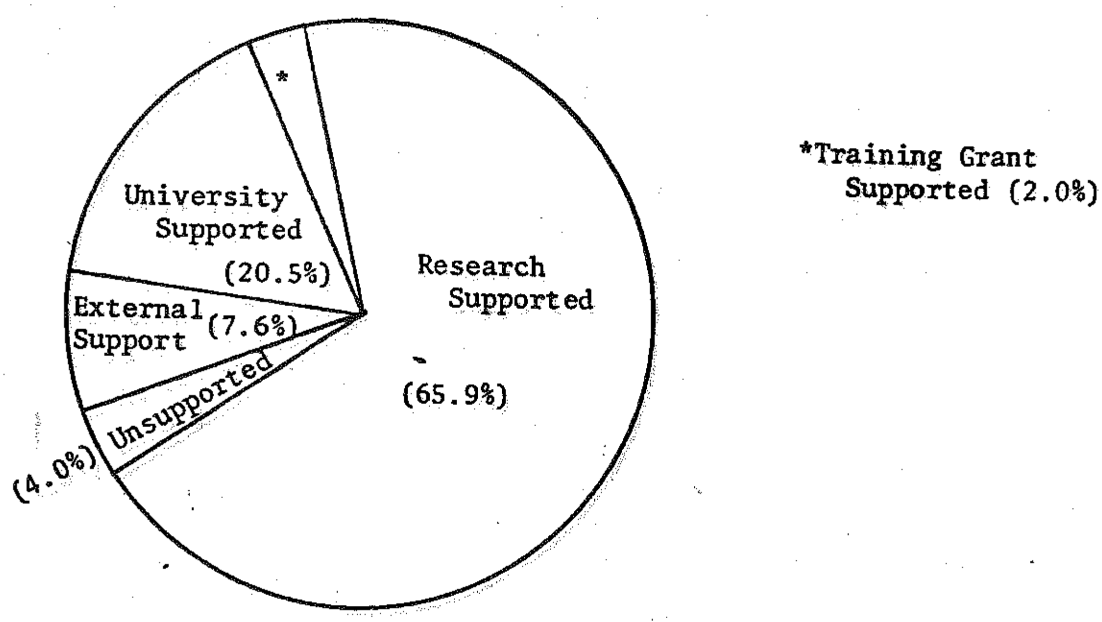
Source of Funding	1969		1979 Full-Time		1979 Part-Time	
	M.S.	Ph.D.	M.S.	Ph.D.	M.S.	Ph.D.
(1) Federal Research Supported (research contracts and grants)	111	65	454.5	164	30	10
(2) Training Grants and Research Fellowships	283	144	99	5	13	4
(3) University Supported (scholarships, teaching, and university financed research assistantships)	32	38	119	51	10	5
(4) Externally Supported (training leaves, foreign governments, international organizations, other support)	111	34	71	19	25	2
(5) Unsupported (personal support or outside work)	160	55	118	10	183	26
TOTALS	697	336	861.5	249	261	47

TABLE 15. Sources of Student Support in Graduate Environmental Engineering Programs by Percentage

Sources of Support	1969		1979 Full-Time		1979 Part-Time	
	M.S.	Ph.D.	M.S.	Ph.D.	M.S.	Ph.D.
(1) Federal Research Supported (research contracts and grants)	15.9	19.3	52.8	65.9	11.5	21.3
(2) Training Grants and Research Fellowships	40.6	42.9	11.5	2.0	5.0	8.5
(3) University Supported (scholarships, teaching and university financed research assistantships)	4.6	11.3	13.8	20.5	3.8	10.6
(4) Externally Supported (training leaves, foreign governments, international organization, other support)	15.9	10.1	8.2	7.6	9.6	4.3
(5) Unsupported (personal support or outside work)	23.0	16.4	13.7	4.0	70.1	55.3
TOTALS	100.0	100.0	100.0	100.0	100.0	100.0



Full-Time M.S.



Full-Time Ph.D.

FIGURE 8. Comparison of Full-Time M.S. and Ph.D. Graduate Student Support in 1979

Water pollution control studies, the major subdivision of environmental engineering science, is an excellent indicator of enrollment trends for the discipline. Figure 9 is a graph first prepared by Jewell and Switzenbaum (1976) and subsequently updated by Aarne Vesilind. The decline in graduate students observed in 1976 appears to have leveled off and may now be on the rise.

Possible reasons for the apparent decline in graduate students enrolled in environmental engineering programs may be the reduction of training grant funds and higher starting salaries at the B.S. level. The incentive to continue graduate education appears lessened by job availability and high wages.

Three questions concerning evaluation of research trends were asked in the AEEP Research Committee Survey. The questions and results are as follows:

--If trends remain towards research support rather than training support, will your program change in size and strength:

16.1% - expand
66.1% - remain the same
6.5% - diminish to acceptable, steady, state level
11.3% - diminish to unacceptable, steady, state level

--How difficult have your recent efforts been to find alternatives to research support from EPA?

51.6% - provide organized efforts to bring together key research personnel of federal agencies, university researchers and users of research results to emphasize the importance of support for university research
32.8% - provide passive assistance to programs by maintaining information exchange regarding potential agency support areas, e.g., through the Newsletter and AEEP meetings
15.6% - other

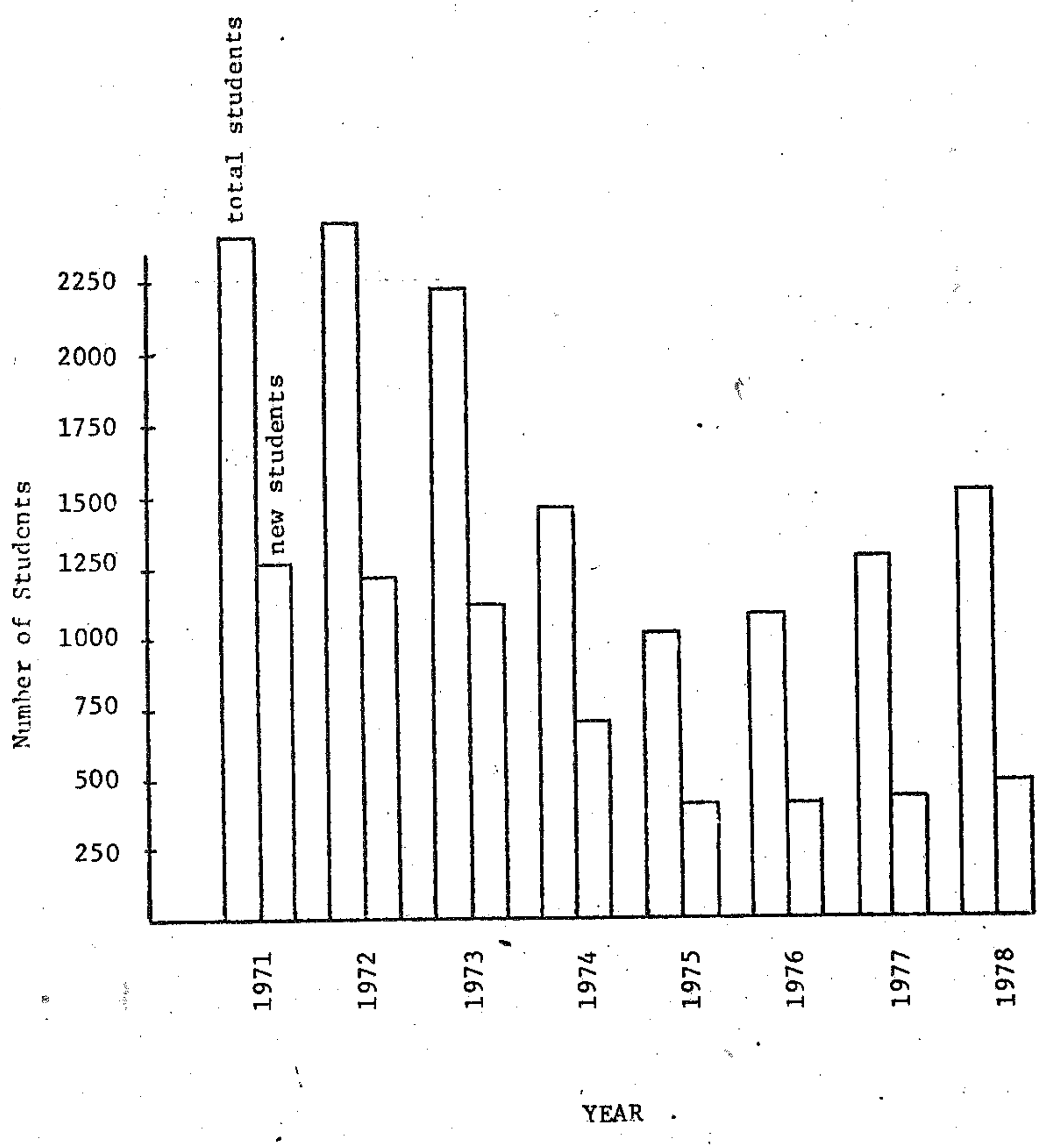


FIGURE 9. Summary of the Eight-Year Change in Graduate Student Enrollment in Water Pollution Control Studies

The responses indicate that future research support will be much the same as it is today. Few environmental engineering programs are expected to expand or diminish in the next few years.

The role of AEEP in research was seen by most as providing organized efforts to emphasize the support of university research. Other services of AEEP expected by some include congressional lobbying for grants, pressure on funding agencies, more interest in state matching funds, and convincing industry, state agencies, and other funding agencies to put more money into research.

A recent problem at some universities that could require the efforts of AEEP is the elimination of both out-of-state and in-state tuition waivers.

At many schools this could raise the cost of supporting a GRA above that of hiring nonstudent research associates.

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POSITION PAPER

EXCELLENCE IN ENVIRONMENTAL ENGINEERING EDUCATION

Perry L. McCarty, Co-chairman
Charles R. O'Melia, Co-chairman
Richard I. Dick
James J. Morgan
Federick G. Pohland
Thomas L. Theis
H. D. Tomlinson

CONTENTS

EXCELLENCE IN ENVIRONMENTAL ENGINEERING EDUCATION

Work Group Co-Leaders: Perry L. McCarty
Charles R. O'Melia

Albert Einstein stated in 1931:

> It is not enough that you should understand about applied science in order that your work may increase man's blessings. Concern for man himself and his fate must always form the chief interest of all technical endeavors, . . .

Environmental engineers are entrusted with the responsibility for the protection of man and the environment. As described at the Third National Conference on Environmental Engineering Education in 1973, the environmental engineer ". . . is concerned with the application of scientific principles for (1) the protection of human populations from the effects of adverse environmental factors, (2) the protection of environments, both local and global, from the potentially deleterious effects of human activities, and (3) the improvement of environmental quality for man's health and well-being." These significant responsibilities carry with them an implied need for excellence, perhaps more so than in any other branch of engineering or science. They require the best that educators and their present and former students can give to the profession and to society.

What is meant by excellence in environmental engineering education? Each person no doubt has his own concept of excellence and uses this to weigh the qualities of educational institutions, educational programs, research activities, educators, and fellow students and practitioners. Some may feel that the excellent institutions are those which contribute most to the development of knowledge by being at the forefront in research, others value those with professors who provide students with information of most value to their professional activities, while still others may rank institutions high if they provide important scientific insites into environmental problems and stimulate the students to greater quests for knowledge. Each tends to judge programs based upon his or her own standards, hopes, and aspirations. A common view of excellence is that it applies only to those few institutions which are at the peak in terms of faculty distinction, student selectivity, and curriculum difficulty. Is this the idea of excellence toward which we should strive, or is there another concept which is more meaningful for all educational institutions, whether large or small, and whether they emphasize undergraduate, post-baccalaureate, or advanced graduate education? Because of the lack of a general consensus on the meaning of excellence, it is desirable first to consider some of the issues involved.

Excellence - A Concept For Some Or For All?

In his book on "Excellence" written in 1961, John Gardner developed a concept of excellence in education which the task group felt was most pertinent for application to the issues being discussed at this Fourth National Conference on Environmental Engineering Education. He raised the question of whether it is possible to have excellence in education and at the same time to seek to educate everyone to the limit of his ability, and reached the conclusion that ". . . A society such as ours has no choice but to seek the development of human potentialities at all levels. It takes more than an educated elite to run a complex, technological society . . . We must seek excellence in a context of concern for all." He suggested there is a kind of excellence within the reach of every institution, and rejected the notion that excellence is something that can only be experienced in the most rarified strata of higher education. To emphasize his point, Gardner stated:

> An excellent plumber is infinitely more admirable than an incompetent philosopher. The society which scorns excellence in plumbing because plumbing is a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water.

The view that excellence is a characteristic within the grasp of every environmental engineering program is one which the task group has taken. Excellence is determined by the degree to which a particular program meets its own goals, as well as by the contribution of those goals to the protection of man and the environment. But how can this concept be applied to the diversity of programs and needs within the environmental engineering profession?

Nature Of Environmental Engineering Programs

The environmental engineering profession is a relatively small one with only a few hundred graduate degrees awarded per year. Yet the scope of activities performed is very broad, not only as suggested by the definition* of an environmental engineer as given at the preceding conference, but also by the experience of professionals in practice. In addition, there are many environmental engineering educational programs in the United States, which means that the average number of graduates per program is relatively small. It was not the purpose of this task group to address the adequacy of the number of graduates to meet the needs of the country, nor of the proper balance between number of educational programs and number of students. Nevertheless it is clear that since the number of students per program is relatively small, a given program can support, on the average, a relatively small faculty. While a few programs are larger, most have no more than three or four faculty members with emphasis in the environmental engineering area.

How can the small programs strive for excellence? Should each strive for balance in the educational staff so that all areas of environmental engineering practice are covered, or should each develop its own unique area of competence? Should all have an active research program, or should some concentrate primarily on education and others on research? How can the proper role for a given program be established? While these are difficult questions, the task group felt it was clear that whatever a given institution saw as its goal in environmental engineering education, it should strive for excellence in reaching that goal. The task group, however, also felt that it was important to address the question of diversity versus uniformity in program development.

Diversity Of Programs - An Ecological Viewpoint

The above arguments make it clear that with the present ratio of graduate students per program, the number of faculty members with expertise in the environmental area in each program, by necessity, will be small. Each member cannot expect to become an expert in all environmental fields, and thus with limited faculty, it would be difficult, if not impossible, to provide excellence in all areas of the environmental engineering field at a given institution. Furthermore, even if this were possible, a student cannot expect to grasp the necessary details within a single one- or two-year graduate program to allow him to perform with excellence in all areas of environmental engineering activity.

However, the overall needs of society cannot be solved only by jacks-of-all-trades in the environmental engineering field, although they have their place. Societal needs also require engineers and scientists with special competence in each area of the field. The major need is for individual experts who collectively can help solve the pressing problems of the environment. The argument then is for a diversity of programs, each of which is seeking to educate with excellence, engineers who can solve specialized as well as more general problems. The capability and stability of the environmental engineering field in the face of new environmental problems is strengthened by the number and diversity of our present programs. The overall needs of society can be solved by experts with a diversity of capabilities working individually or together. Again, borrowing from the arguments by John Gardner:

> . . . we must cultivate diversity in our higher educational system to correspond to the diversity of the clientele . . . We do not want all institutions to be alike. We want institutions to develop their individualities and to keep those individualities. None should be ashamed of its distinctive features so long as it is doing something that contributes importantly to the total pattern, and so long as it is striving for excellence in performance . . . Each institution should pride itself on the role that it has chosen to play and on the special contribution which it makes to the total pattern . . . We must have diversity, but we must also expect that every institution which makes up that diversity will be striving, in its own way, for excellence.

The task group is thus encouraging a diversity of environmental engineering programs, each with its own defined area of emphasis, and each in its own way seeking excellence in the education of engineers and scientists to help solve the environmental problems of society. Each program should examine its own strengths in the light of societal needs, and should strive to develop its program to provide the highest quality of education possible. In this way, the overall needs of society can best be served.

Thus, each environmental engineering program should examine the strengths within its own group of faculty, within the Department or School in which it resides, and within other parts of the University to determine what type of educational and research program it can best provide with excellence. Expansion, when possible, should then be done to build upon the strengths already at hand, and to either broaden that strength into other complementary areas, or increase it within the same area, whatever seems most appropriate to the goals of that particular university.

Some programs will find that their strength lies in a good masters degree program to educate engineers for practice in a given field, such as water control or air pollution control. Others may decide that their particular strength lies in their undergraduate program, and may conclude that provision of a sound background in appropriate engineering and science disciplines for students desiring to pursue graduate work in environmental engineering at some other institution would allow them to develop a program with excellence. Others may conclude that the faculty attributes, the laboratory facilities, and the capabilities of the student body are such that an active environmental research program and education of post-masters degree students is what they can do with special competence. Building upon ones own particular strengths to provide a program of excellence regardless of the degree level or area of environmental engineering should be the goal of all programs. What is needed are steeples of excellence in environmental engineering education throughout the country. These steeples, and their particular structure, should be recognized so that a student with particular interests can find those institutions which can best satisfy his background and career goals.

With small faculties, some may wish to provide educational programs which emphasize water quality control and treatment processes. Others may wish to do the same in air pollution control. Some may find that because of their particular faculty, a water quality emphasis combined with other water-related areas such as hydrology and fluid mechanics would be most appropriate; others might find that a combination with courses on infrastructure planning and management would be particularly appropriate for them. Some will conclude that their strength lies in a combination of water pollution and air pollution control, or perhaps in these in combination with courses in solid waste disposal. Universities with larger faculties may find that they can offer excellence in education in two, three, or perhaps more areas.

The task group was thus of the belief that to have excellence in educational programs, they should not be encouraged to look alike, but rather should be encouraged to define their particular unique qualities, and to build their strengths around this uniqueness. Now this is not to infer that some base level of offerings in mathematics, chemistry, biology, and engineering should not be expected in all environmental engineering programs, but rather that the excellence of a program depends upon what is built over this base level. A base level of courses is generally what the profession feels is minimum background for environmental engineers. However, excellence in education is more a function of depth or breadth of understanding which one is able to acquire beyond this minimum.

Within the concept of excellence being developed, the size of faculty is not a governing factor beyond some minimum level. Pragmatically, however, the faculty specializing in environmental engineering for a graduate program should probably not be fewer than about three individuals since a smaller program will have difficulty in offering a sufficient breadth of offerings, and the program will be vulnerable to absence of faculty because of sabbatical leaves, retirements, or other temporary changes. Perhaps a minimum of four faculty is sufficient to give a program stability. Probably most can think of programs which they consider to be excellent that have no more than three to four faculty members. Numbers beyond this, however, do increase the stability of programs and also permit them to have a greater breadth of offerings. Programs with larger faculties have better opportunity to develop excellence, but certainly faculty size by itself does not constitute a measure of excellence. Thus, excellence in the educational program is possible within small as well as large programs. The task group considers that the quality of excellence cannot and should not be judged by program size.

Curriculum Content

As already discussed, the curriculum content of a program is not the determining factor in judging its excellence. However, there is a basic aspect of education which is part of an excellent program, and this is more related to emphasis within the curriculum rather than its content. Excellence means a striving towards a high level performance, and an encouragement of one to achieve the best that is possible. Attitudes towards growth and learning must be instilled in the students, and a level of creativity must be encouraged which will help shape the direction the profession takes in the future.

The most obvious lesson from the past decade is that our graduates must be prepared for change. Solutions to environmental problems which were once thought to be futuristic or impractical are now in common usage. Problems which were too difficult to understand are now being solved. However, at the same time, other problems of even greater complexity have emerged. It is not possible to foretell with certainty today what skills may be most needed by our graduates in the decades ahead. It is thus necessary to educate students in the fundamental fields of knowledge so that they will be well equipped to deal with change. The changes ahead are certain to require many different kinds of complex understanding, and since the breadth required cannot be provided to a single individual or within a given institution, a diversity of programs is needed. However, within those particular programs featuring excellence, the students should be offered a fundamental training which will prepare them for a variety of specific jobs and for change.

A fundamental training requires knowledge in the sciences as well as in engineering. It requires excellence in communication skills as well as technical ability. It is best fostered by a faculty with diverse abilities and backgrounds, and by a faculty which understands the need for, and respects and encourages this diversity. It is also necessary that the faculty not only demand excellence in performance from their students, but also practice it themselves. Thus, the variety of courses taught is not a measure of excellence, but this is dependent upon the emphasis within the courses, the expectations given to the students, and the attitudes of the faculty themselves.

An Environmental View

It is most important that environmental engineers be instilled with the responsibility they have for the maintenance of a safe and wholesome environment. They will be looked upon by society for an understanding of and solutions to environmental problems. They need to grasp the significance not only of the local impacts of pollution, but of the global effects as well. The excellence of the environmental engineering profession will be judged by society by the way the profession comprehends the effects of pollution, by its perspectives on the tradeoffs between control of environmental hazards and other needs of society, and by the solutions it offers to these problems. An environmental engineer is generally regarded as an individual who has sympathy with the need for pollution control, and can be counted upon by society to develop solutions to these needs. Thus, environmental awareness should be part of any program of excellence in the environmental engineering field. Such an awareness is likely to be an obvious part of the lives of the faculty in an excellent program, and will be apparent within the courses taught by the faculty.

Some Concerns

The availability of excellence to all programs does not ensure the development of excellence in all programs. Following are examples of potential difficulties.

Regardless of the program and its goals, environmental engineering students must develop their engineering capabilities in an educational atmosphere that includes knowledge of an interaction with natural sciences. The appropriate mixture of these sciences and engineering will depend on the goals of the program, but the mixture is necessary and it can be delicate. Insufficient education in natural sciences can limit the abilities of engineers to perceive and understand environmental problems, to communicate with environmental scientists, and even to develop useful technical solutions. Overemphasis on science in environmental engineering education can limit the abilities of engineers to develop and evaluate alternative strategies for environmental management and to utilize the art and experience of the engineering profession in providing facilities for solving environmental problems. Given the need for and the existence of diversity in environmental engineering education, no universal curriculum should be expected or sought. Rather, individual programs must actively seek the balance most appropriate to their goals.

The need for education in both natural sciences and engineering has been recognized by past conferences, and is widely accepted and implemented today. There is also a need for educational programs that combine engineering with the humanities and social sciences. This has not been met adequately; it may not even be recognized adequately. There is need for the development of a few experimental programs that are based on foundations in environmental engineering and the social sciences. These programs should focus on identifying and solving real environmental problems. Based on the success of these efforts, education in humanities and the social sciences could be expected to comprise an integral and effective part of environmental engineering education in the future, much in the manner of the incorporation of natural sciences into the field in the past.

Diversity can be constrained by available resources. These are becoming scarce in all fields of engineering at this time. Expanding undergraduate enrollment is coupled with stagnant and even declining enrollment in graduate programs. It has been observed, for example, that the number of assistant professor vacancies in chemical engineering exceeds the number of new doctorates in the field, without even considering the needs for the private and governmental sectors. If additional emphasis is not given to graduate research and doctoral study in environmental engineering, it is plausible and even probable that in future years there will not be a sufficient number of qualified faculty members to educate environmental engineering students and to participate in research to solve environmental problems that grow more complex and perhaps more numerous. A tension between scarcity of resources and the need for a diverse mixture of environmental engineering educational programs with adequate strength in graduate research programs can be anticipated.

Excellent programs require excellent faculty. It has been stated elsewhere that excellent faculty in environmental engineering should demonstrate environmental awareness, should strive for excellence in teaching, and should demand excellence from their students. They should also indicate a concern for new solutions to real problems, and should devote energy and time to interaction with other faculty members. These characteristics are needed for faculty in all programs, undergraduate or graduate, conceptual or practical. Faculty must also remain current. This can be a serious problem with adequate resources and could be even more difficult in the future as resources become scarce, student enrollments increase, and faculty members remain constant or decrease. Faculty require continued education or development.

Their needs may be in practice or in research, but they must be met if excellence is to be obtained and maintained.

Summary

In the view of this task group, excellence within environmental engineering education is available to all programs, whether large or small, and whether they tend to encourage teaching or research. Excellence refers to the development of high standards of performance, near the peak of ones capabilities, and regardless of whether this performance is in research, education, or practice. Excellence can be developed by recognizing the strengths within a given program, and by developing those strengths to the fullest measure possible. Excellence is not a characteristic which is measured by size of faculty, student body, course offerings, or research publications. It is measured by the leadership qualities its graduates display in solving environmental problems, and the high quality of performance they display and demand of their peers and subordinates. Society will best be served by the development of a diversity of excellent programs that collectively satisfy the needs of society for environmental protection.

In developing and sustaining the collective capability of all programs and the excellence of individual programs, some difficulties must be considered. These include but are not restricted to the need for a balance between science and engineering in each program, our present inadequacies in combining social sciences and engineering in education, the current strain on available resources for engineering education, and the need to develop and sustain the capabilties of individual faculty members throughout their careers.

DISCUSSION GROUP REPORT

EXCELLENCE IN ENVIRONMENTAL ENGINEERING EDUCATION

Excellence in environmental engineering education is determined by the degree to which a program meets its educational goals and the contributions of these goals to the overall protection of man and the environment.

Excellence can be achieved by all programs, whether large or small, and whether they tend to encourage teaching or research. Excellence refers to the development of high standards of performance, near the peak of one's capabilities, and regardless of whether this performance is in research, education, or practice. Excellence can be developed by recognizing the strengths within a given program, and by developing those strengths to the fullest measure possible. Excellence is not a characteristic which is measured by the size of faculty, student body, course offerings, or research publications. It is evidenced by the leadership qualities its graduates display in solving environmental problems, and the high quality of performance they display and demand of their peers and subordinates. Society will best be served by the development of a diversity of excellent programs that collectively satisfy the need for protection of man and the environment.

There is a need to establish minimum standards in order to prevent inadequate programs, but quality in environmental engineering education is fostered by minimizing educational constraints to stimulate diversity, creativity, and excellence.

In developing and sustaining the collective capability of all programs and the excellence of individual programs, some concerns must be addressed. Among these are:

1. The current strain on available resources for engineering education.

2. Attracting new faculty into environmental engineering education.

3. The need for a balance between engineering and science in each program.

4. The need for integrations of social sciences with environmental engineering education.

5. Providing opportunities for professional growth of faculty members throughout their careers.

6. Increasing the pool of students attracted to the environmental engineering field.

7. University criteria for faculty performance may act as impediments to the development of quality programs for the protection of man and the environment.

PLENARY SESSION ACTIONS

EXCELLENCE IN ENVIRONMENTAL ENGINEERING EDUCATION

The discussion group report was presented to the plenary session by Charlie O'Melia and Perry McCarty.

Hal Cooper moved to accept the report and the position paper. Steve Shelton seconded the motion. A period of discussion followed. Walt Purdom felt the wording of Item No. 7 implied desire for no criteria to be applied to faculty. Charlie O'Melia indicated that support material defining this would be provided.

Jim Morgan moved to add the word some at the beginning of Item 7 in the report. The motion was seconded by Hillel Shuval. The motion passed unanimously.

Shuval had a problem with semantics of the first section. He felt that protection of man and the environment is not specific to engineering education alone.

The vote was taken on the original motion and it passed unanimously. Rolf Kayser suggested shortening the section but Jack Nesbitt felt that there really was no problem. Frank Parker suggested reversing the wording and expanding items to give ideas on how to accomplish these goals (while this was implied to be a motion for submission at a later time, this comment ended up being a recommendation only).

A number of other comments were made as directives to the work group.

POSITION PAPER

COMPREHENSIVE VS SPECIALIST PROGRAMS IN ENVIRONMENTAL ENGINEERING EDUCATION

Paul Busch, Co-chairman
Daniel A. Okun, Co-chairman
Richard Conway
Cliff I. Davidson
Benjamin C. Dysart
Robert Harris
David Jenkins
Francois M. M. Morel
Charles Revelle
Donald R. Washington

CONTENTS

Contents and Summary of Issues and Recommendations

Obligations vs. Opportunities for Breadth in Environmental Engineering Education

- Breadth may (1) include more than one medium, such as air pollution control for those who are interested in water; or it may (2) include fields that influence implementation of programs, such as law, economics, public administration

- Should such breadth be mandatory for all students, or at the least, should opportunities for such breadth be available at all institutions?

Approaches to Providing Breadth in Environmental Engineering Education

- Problems in providing breadth

- Options for providing breadth: addition of courses; integration of materials into existing courses; interdisciplinary programs; lecture and seminar series; use of outside professionals; case studies

Approaches to Strengthening Specialized Education in Environmental Engineering

The practice of Environmental Engineering calls upon knowledge in the technical fields of water, air, and solid waste management. In addition, the fields of law, economics, public administration, finance, planning, and other social sciences impact upon the application from the technical fields to societal needs.

Obligations vs. Opportunities for Breadth in Environmental Engineering Education

Most educators would agree that, if engineers are ever to escape from the stigma of being the people who paved America, they must broaden their set of concerns from the technological to include humane and economic issues. Engineers should be exposed to both the triumphs and the failures of technology - the automobile which gave America mobility and which gave America smog; the power plants that light our lives and complicate our lives with their demands for fuel and their pollution outputs. Should engineers emerge from their education without knowledge that technology does not solve all problems?

The principal issues may be categorized as follows:

1. Should all Masters candidates in Environmental Engineering be obliged to either (a) undertake studies; or (b) have the opportunity to undertake studies, at some minimum level, in the three fields of water, air, and solid waste management?

2. Should all Masters candidates in Environmental Engineering be obliged to either (a) undertake studies; or (b) have the opportunity to undertake studies, at some minimum level, in those fields which influence the implementation of environmental activities such as law, public administration, economics, finance, and the social sciences?

Discussion

The matter of requiring that programs of study, whether to encompass all the media (water, air, and land) or to include the relevant institutional skills of law and economics and the like, be mandatory for all students aspiring to masters degrees in environmental engineering is a matter of educational philosophy, and might well be addressed by this conference. As appealing as such a requirement might be, several problems arise:

1. Students interested in professional practice or research in one of the specific fields or subfields of environmental engineering, say water filtration, may be put off and exhibit little interest in materials that are not believed to be essential to their field of study. Time that might otherwise be devoted to studying the chemistry, biology, and hydrodynamic aspects of filtration would have to be spent on what appears to the student to be peripheral subject matter.

2. Educational institutions may not have the resources to provide adequate education in the many fields necessary for such comprehensive programs.

3. Time is a constraint to both students and educators in providing adequate coverage in the fields mentioned.

4. Students may not be adequately prepared in their undergraduate engineering programs to undertake meaningful study in some of these fields.

Given the diversity and number of institutions engaged in environmental engineering education, is it necessary that all programs offer the full range of opportunities indicated? Conversely, would it be appropriate to have each institution build upon its strengths, allowing the prospective student to become informed as to those institutions that demonstrate the capacity and willingness to meet the student's needs?

This issue can be put another way. Is it necessary for every Masters graduate in environmental engineering to take any prescribed course of study, whether to insure breadth or depth? If the answer is "no," then we might go no further on this issue. On the other hand, even if the answer is that there be no prescriptions, environmental engineers and educators would be discomfited without any guidelines whatsoever. Furthermore, given the present climate regarding environmental quality, most students will undoubtedly seek opportunities to explore many of the fields that comprise and impact upon environmental engineering.

This approach to education places burdens upon both the prospective student and the educational institution. The prospective student is obliged to learn enough of the entire field to make, at the least, a preliminary selection of his/her area or areas of interest. At the same time, the educational institutions must make available to prospective students information concerning the breadth and depth of their programs. Otherwise, both student and institutions may be disappointed with the outcome.

Thus, one clear conclusion may be drawn, regardless of how the issues stated are resolved:

The educational institutions should make available to prospective graduate students information concerning the faculty resources and the fields of study available at their institutions. The AAEE and AEEP may assist in this by providing a suitable format for this information and by providing vehicles for communication of this information to the pool of prospective students.

Approaches to Providing Breadth in Programs

Whether or not an institution will require that its students take a minimum mandatory program, most institutions will find it appropriate to provide, at the very least, opportunities for their students and faculty to engage in studies that involve several of the technical fields of environmental engineering. In addition, or alternatively, they may want to become involved with those fields that are concerned with the implementation of environmental engineering activities in society. Serious problems must be overcome if such opportunities in environmental engineering graduate programs are to be provided. Among these problems are:

1. Limited financial resources.

2. Traditional organizational constraints that compartmentalize fields and disciplines.

3. Educational reward systems which encourage specialization and discourage initiatives towards joint enterprise with colleagues in related fields.

4. Limited educational resources such as the unavailability of a law school, public health school, or other allied academic endeavors.

5. Time constraints that restrict opportunities for faculty and students to explore the other resources at the educational institution.

Discussion

No specific approach can be expected to entirely resolve these problems because of their diversity and because of the unique character of each educational institution. However, many avenues are available for approaching these problems. Each institution may select those that are most appropriate to its resources and objectives. Hopefully, the availability of these avenues may foster objectives that might otherwise not be attempted. Some approaches that may be considered are listed below without any implication of priority.

1. Addition of courses - This is perhaps the most conventional approach. Such courses are often titled "The Social Impact of Technology" or "Technology and Society." However, this approach may be less satisfactory than others. It suffers from the danger of irrelevancy, of possible inappropriate level of instruction, and many of

the problems enumerated above. A decision as to which school or department should offer such courses may also constitute a problem.

2. Integration of related materials into existing courses - For example, courses on wastewater treatment processes might include material on the air pollution and solid waste disposal problems that are an integral part of the processes studies. Or a course on water supply might include problems of regulatory constraints and their appropriateness, financing, and land-use planning.

This approach, too, is not without problems. Instructors in a technical field may not be competent to deal effectively with these auxiliary materials. The introduction of these materials may dilute the content of the course. If this approach is believed to have merit, faculty interested in attaining competency in related fields of study so that they may be integrated into their own courses may be encouraged to explore opportunities for personal enrichment from outside their own departments of university.

Another possibility is the participation in the course of instructors competent in the related fields, with the caveat that such participation must be well integrated and supervised by the course instructor.

3. Interdisciplinary programs - Two general arrangements are possible. The several disciplines may be brought together into one department, school, or other academic unit that is responsible for the funding and management of all of the activities within its purview. The other approach is the institute or center that draws faculty from home departments for service to the environmental engineering program. The latter approach is more appealing in that it does not involve upsetting existing, well-established university departments. On the other hand, without exceptionally strong leadership, it is not likely to be successful, as the university reward structure does not encourage loyalty to such centers.

4. Seminars and lecture series - Educational institutions offer many vehicles for education outside the formal classroom. Seminars and lecture series offer a wide variety of opportunities for introducing experts and experiences from related fields

to students in environmental engineering. This has the additional advantage of providing an opportunity to bring in role models in addition to the immediate faculty. One problem with this approach is the energy required to devise, implement, and continue such programs. Another may be the unavailability of funds for outside lectures. However, it may be possible to explore faculty resources within the institution, or from government, consulting engineers, and industry at little cost to the program.

5. Use of outside professionals - Professionals in the field have an obligation to participate in the education and development of new generations of professionals. They also have an interest in participating in educational programs to help them identify prospective professionals with whom they will associate in the future. Professionals may be used in a wide variety of ways, including roles as adjunct professors, teaching courses or leading seminars, guiding individual graduate students, joining research efforts and the like. Externships for students and faculty in consulting engineering organizations, industries, municipal facilities, and government agencies can bring active professionals into profitable contact with students and faculty. (See Table 16 for partial listing.) Maintaining quality will be important.

6. Case studies - Case studies in environmental engineering education can be utilized in both small and large contexts. The former is easily applied by the individual teacher. The latter, which may be most fruitful in integrating the various technical fields of environmental engineering and relating them to societal needs and constraints, may require cooperative enterprise on the part of faculty and professionals from a wide variety of fields. Because the materials required for case studies is costly in time and effort and difficult to accumulate, the development of a library of case studies by AAEE and AEEP may be a most useful service to the educational community. Case studies may illuminate how changes in technology and societal factors affect the solution to specific environmental problems. Many sources of materials for case studies are available, such as EPA's Industrial Profiles for Environmental Use which provide a data base for multimedia studies. Case studies may be based on several types of characterization:

TABLE 16.* Roles for Practitioners in Education of Graduate Students

1. Teach a course under an adjunct appointment.

2. Aid in development of a course in an emerging technical area, such as hazardous solid waste disposal or ecological fate/effects of chemicals.

3. Serve as quest lecturer in a course, either in regard to a theoretical area in which they are specialists or in regard to discussion of specific projects and problems as case studies.

4. Present their work experience as part of a seminar series.

5. Supervise a thesis or special problem; studies could be done at the educational institution under a "co-op" arrangement.

6. Provide a list of projects from the "real world" for special problems or theses.

7. Serve on an advisory committee on curriculum development to help ensure graduates can fill near-term and future needs in the profession.

8. Arrange grants for research work which will further graduate education and provide information needed by the firm, industry, or government agency.

9. Participate in development of non-credit short courses, i.e., identify the need and help recruit students and/or subsidize.

10. Set up a joint use of consultants; those specialists that are recruited in the area could also lecture at local educational institutions the same day.

11. Arrange consulting opportunities within industry, consulting organizations, and government for full-time faculty.

12. Provide facilities and opportunities for laboratory and field activities in support of courses.

13. Recommend materials for library collections of academic institutions.

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* For inclusion in COMPREHENSIVE VS SPECIALIST PROGRAMS IN ENVIRONMENTAL ENGINEERING EDUCATION.

a. <u>Source Specific</u>: Example, steam electric power plants. Involved are problems in air pollution, cooling water thermal problems, ash disposal, sludge disposal (with flue gas desulfurization), and many economic, legal, and regulatory aspects.

b. <u>Agent Specific</u>: Example, sulfur oxides. The generation, transport, fate, and emission control technology could be addressed. Concerns include SO_2 air pollution per se, sulfates, acid rain and its consequences in soil, streams, and lakes, and the technical and institutional problems of abatement.

c. <u>Program Specific</u>: Example, Federal motor vehicle emission control program. This program has intricate interrelationships between technical, legislative, regulatory, fuels use, and energy policy issues. This could be a massive case study; the lead additive aspect alone (impact on air, land, and water) could be a complex case study.

d. <u>Episode Specific</u>: Example, studies of the discharges of PCB materials along North Carolina roadsides, or the kepone episode on the James River would integrate the problems of air, water, and land contamination. Concerns of the general population, government, the scientific community, and legal issues are also involved. These episodes clearly illustrate institutional problems and the need for pre-planning for episode-response situations.

e. <u>Problem Specific</u>: Example, implications of prohibition of sludge discharge to the ocean. Requires sludge treatment on-land by processing (incineration and drying produce air pollutants in critical air basins; composting and land-fill produce leachates) or by land application (produces salt accumulation and more direct route of toxicants to animals and man than sea disposal).

Strengthening Specialized Education in Environmental Engineering

Many institutions may work to develop depth in one or more fields of technical specialization in environmental engineering. This approach tends to pose fewer barriers in academia because it is in accordance with most univeristy departmental organization and policy. Also, outside funds may be more readily available for supporting discipline-related activities. Nevertheless, resources may be limited and many of the avenues explored above in Section 5 are equally applicable to such development.

DISCUSSION GROUP REPORT

COMPREHENSIVE *VS* SPECIALIST PROGRAMS IN ENVIRONMENTAL ENGINEERING EDUCATION

A far-ranging discussion paper was prepared by a task force and distributed in advance of the Fourth Conference. The day and a half devoted to review, discussion, and further deliberation was actively participated in by approximately 50 different individuals.

A wide variety of faculty from environmental engineering academic programs and numerous key personnel from some of the leading consulting engineering firms were present and contributed their views and experiences. Because of this, the recommendations produced should be of considerable application and value. While there was considerable debate, often times spirited, broad concensus was reached on all three major points, as well as approaches for implementation.

It was agreed that two types of broadening are desirable, indeed necessary, in environmental engineering graduate programs: those aspects dealing with media and those aspects dealing with the societal dimensions. First, graduates must be aware of the importance of the air, water, and land aspects of pollution control and environmental management in general. Implicit in this is also an awareness of the occupational health and radiological health engineering aspects. Second, the societal dimensions include economic, legal, social, institutional, political, and communications aspects.

It was recognized that environmental engineers must have an understanding of the relationships between and transfer of environmental problems among the several media. This is necessary for the graduates to do an adequate job when employed, to be useful and flexible as a professional, to avoid limitations to their professional advancement, to produce more implementable solutions to important environmental problems, and to avoid inappropriate solutions.

It was also recognized that environmental engineers can be most effective and productive for themselves and society when they understand where environmental engineers, engineering, science, and technology fit into the entire environmental decisionmaking process. In this way, they may have a greater beneficial impact and contribute more substantially to producing better-informed, more cost-effective, and more acceptable solutions to problems.

It was recognized that the implementation of measures to achieve the first two items agreed upon would differ from academic program to academic program. Fortunately, there is a wide variety of options which may be elected. Those elected for use in an individual program must, of necessity, be a function of the strengths and orientation of the program, the preferences of its faculty, local institutional factors and needs, and availability of resources. While it is intended that these broadening opportunities be flexible, students should be encouraged to avail themselves of them.

The third item agreed upon was the desirability, in fact the necessity, of maintaining adequate depth in the fundamentals and the technological aspects so critical for sound achievement in professional practice. As with the two broadening items, there are numerous options available.

<u>Integration of Breadth into Existing Courses</u>

1. Where faculty resources or student time are limited, a useful approach to providing breadth is by integrating appropriate material into existing courses. While it is best that the instructor have the background to relate the problems of one medium to that of another and to identify the societal, economic, and institutional constraints in the implementation of projects, it may be necessary to seek assistance from competent professionals outside the department or even outside the university. However, it is mandatory that the contributions of such "guests" be fully integrated into the courses, and this requires that the instructor be an active participant when the guests are present.

2. In order to help faculty, who do not already have it, to attain competence in the subject areas that are important to achieving adequate breadth, they should be encouraged or even required to engage in professional consulting and to serve on committees of professional organizations such as the National Research Council.

3. In recruiting new faculty to programs that do not have adequate breadth available to them, the institutions should seek to identify candidates who have the requisite broad background obtained either through their academic programs or preferably through prior employment in the field.

4. To assist faculty in the presentation of relevant material from the related fields, whether other media or the social sciences, writers of texts and reference books should be encouraged to identify the relationships among the media and the significance of the institutional, economic, and social settings that are applicable.

5. A device for enocuraging breadth is the invitation of appropriate professionals from the field to the university for short or long periods of time. Their contributions to coursework and student guidance may be invaluable.

Multidisciplinary Programs for Added Breadth

1. In some institutions, multidisciplinary teaching and/or research programs that involve two or more media or that relate the institutional and technical problems can serve to bring breadth to environmental programs. These can be mounted in many different ways, among which are the creation of departments that are themselves multidisciplinary or institutes or centers that draw upon faculty and students from a wide range of educational units.

2. However, for such programs to be successful in the long term, they need to be properly established with incentives that would encourage the best of the faculty from the relevant departments to participate. Such incentives include adequate renumeration, promotion, and university support.

Guidance to Prospective Graduate Students

Because it is not intended that all programs have all the resources for the various options discussed herein, prospective students must be made aware of the special character of each of the programs so that intelligent educational decisions can be reached. One valuable device for appraising students and their advisors of the strengths of the programs in the field is the Register published by AAEE and AEEP. However, because distribution of the Register is limited, it is recommended that the publishers prepare a brochure for wide distribution among prospective graduate students that would inform them of the nature and rewards of graduate education in the environmental field and that would indicate how and where they can avail themselves of guidance. In addition, the Register should contain a brief summary of its contents for distribution to interested applicants that would indicate where specific programs of study and research are available.

Provide Breadth through Course Addition

Encourage consideration of one or more of the following within the limits of students' time and institutional resources:

a. Where existing courses in related fields are available which would lead breadth to the educational experience, students should be encouraged to avail themselves of them.

b. Provision or a common "Exposure" course for all.

c. Addition of one or more new courses to the program.

Case Studies

Case studies of actual problems were viewed as a utilitarian approach to achieve breadth in both technical subjects and societal areas. The material for the case studies should include the societal issues (such as legal, political, social, financial, regulatory, and public information and acceptance) as well as the technological issues. These case studies could be comprised of formally packaged material integrated into a course or informal material integrated into existing courses.

Encouragement to have students actively study local controversial environmental issues also is considered part of the case study method.

It is desirable that AEEP and/or AAEE consider taking responsibility for preparation and publication of a collection of significant case studies.

Lectures and Seminars

One technique to broaden student understanding of related fields and multidisciplinary problems is to provide lectures and/or seminars by experts who have been involved with a particular problem or concept. Resources for these problems may be available from within the institution or from government, consulting engineers, and industry. In some instances, the students themselves have prepared and presented the programs. Experience has shown that all such programs are most effective when followed up by subsequent discussion in the classroom. Such programs can be used as a supplement to faculty efforts to point out "other media" and societal dimensions throughout most existing courses.

<u>Specialist Programs</u>
Graduate programs have most commonly provided education in one or more of the various specialities of environmental engineering. Even as institutions are encouraged to broaden their programs, advancement of the field requires education and research in depth. Although such depth may not be feasible in all programs, certain elements should be embodied in most programs, with particular emphasis on problem formulation.

Among these are:

- Computer programming
- Applied mathematics
- Fluid mechanics
- Materials and energy balances
- Oral and written communication

Perhaps the best approach to specialist preparation is involvement in projects and/or research. Accordingly, a master's project or thesis, in which the student formulates a problem and sees to its execution and presentation, is an important tool to building professional competence, not only in an area of specialty but in project design and implementation. Students may be excused from this requirement when they have demonstrated equivalent performance in their professional careers.

<u>Improving the Capabilities of Programs</u>
Whether the need is to strengthen the comprehensive or specialist quality of educational programs, two low-cost approaches are available.

1. <u>Continued Education for Faculty</u>
   Faculty should be encouraged to keep up to date by taking sabbatical leaves, attending short courses and symposia, and by seeking enrichment in any ways that are appropriate.

2. Use of Outside Professionals

Professionals in the field should be encouraged to participate in the education of graduate students within the framework of supplementing the program at each institution. A broad spectrum of interested practitioners is usually available to provide knowledge and experience outside the normal sphere of the program faculty. These individuals may be used as adjunct or visiting professors, guest lecturers, case study source material, specialists in emerging technical areas, etc. It may also be possible to develop student internships with these individuals and their organizations.

PLENARY SESSION ACTION

COMPREHENSIVE VS SPECIALIST PROGRAMS IN ENVIRONMENTAL ENGINEERING GRADUATE EDUCATION

The discussion group report was presented by Paul Busch and Dan Okun. Dan Okun moved for acceptance of the report as presented. Rolf Kayser seconded the motion which passed without discussion or opposition.

POSITION PAPER

CURRICULAR BALANCE IN ENVIRONMENTAL ENGINEERING EDUCATION

Ernest F. Gloyna, Co-chairman
Hal B. Cooper, Jr., Co-chairman
Neal E. Armstrong
George Belfort
Robert B. Grieves
Charles N. Haas
Michael J. Humerick
David Jenkins
Desmond Lawler
Joe O. Ledbetter
Cecil Lue-Hing
Gerald A. Roblich
Thomas L. Theis
Walter J. Weber, Jr.

CURRICULAR BALANCE IN ENVIRONMENTAL ENGINEERING EDUCATION

Why should curricular balance in environmental engineering education concern an international gathering, or any national body? Aren't all of us representatives of centers of academic excellence? Don't all of you recognize that there is no substitute for quality education? Is our concern caused by a growing awareness that a significant amount of "environmental" education may not be meeting the test in the market place when compared with modern traditional degree programs?

We environmental engineers need to ask ourselves a very basic question. Just what do we provide that an outstanding B.S., M.S., or Ph.D./Dr. of Engineering degree in a basic engineering discipline cannot provide? Remember that there are growing opportunities for continuing engineering education and advanced-level degree plans. Obviously, all of us want our graduates to compete with the best that engineering education has to offer for furthering their careers.

The point of the above commentary is to illustrate that educational institutions have a great degree of flexibility in establishing and maintaining student quality. Also, environmental engineering has become in some cases, a dilute course of study ranging from undergraduate environmental science and technology to a multitude of graduate courses culminating in a variety of doctoral specialities. Yet, there seems to be a strong justification to provide an educational base that is not adequately covered in the traditional engineering programs. However, in filling this void, it is necessary to provide rigor and quality that results in well-educated graduates at all degree levels.

To cope with an analysis of the questions that may be suggested by proponents or opponents of a curriculum in transition, it is suggested that this discussion be limited to that component of "environmental" education which has its fundamental bases in engineering and science. Engineering concepts to be incorporated include both design and synthesis. The respective sciences to be incorporated in environmental engineering programs related to the specific fields of interest.

Definitions

The Engineers Council for Professional Development (ECPD), since January 1, 1980, the Accreditation Board of Engineering and Technology, Inc. (ABET), defines "engineering" as:

> the profession in which a knowledge of mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize economically, the materials and forces of nature for the benefit of mankind. Similarly, engineering technology is defined as, "the part of the technological field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer."

Dr. Charles Stark Draper, in his address before the National Academy of Engineering, accurately summed up the philosophy of engineering education:[(1)]

> There is not enough attention given to the detection and development of potentially creative talents of students. The generalized overall objectives of engineering may be reasonably taken as service to society in providing comprehensive information on possibilities and forms of optional decisions in terms of plans for meeting given specifications of desired results.
>
> Beyond academic work, the coupling to professional practice is best achieved by experience with responsibility in real world technological developments of accepted significance. This experience has its greatest usefulness only if it includes planning, management, and control of personnel relationships. With an educational background of this kind, engineers with firm knowledge of science, mathematics, and accepted methods based on comprehensive practice in pioneering technology and competence to deal with human problems, complimented by developed habits of creative thinking and leadership, will provide engineers able to give earth's population of the future the best possible human testing.

More specifically it is suggested that any environmental engineering curriculum must have as a minimum the basic science and engineering design and synthesis which would meet the minimum ECPD/ABET requirements. These basic requirements will be discussed in greater length in subsequent sections of the position paper. Much has been written about engineering curricula in the past. The three previous National Conferences on Environmental Education have helped to keep the subject alive.[2]

Educational Needs

The projection of education and training needs for environmental engineers in both the private and public sectors over the next two decades presents a challenge. There are many important environmental problems which must receive attention. The magnitude and complexity of environmental problems will grow in the future with the corresponding need for developing and implementing more diverse and sophisticated solutions involving "preventive" as well as "treatment" approaches. The increasingly complex regulatory web created by Federal environmental legislation mandates that these solutions be resolved through better technical and legal means.

Many of these environmental problems are going to be solved in terms of better process designs, in the resolution of issues in the areas of public affairs, in the optimization of finances, and in the utilization of better trained technologists or technicians. These individuals will not necessarily be specialists who will have had advanced-level education in an environmental engineering program. More people who have received degrees in traditional degree programs are likely to be involved. Nevertheless, there will be a need for environmental engineers who will have had advanced-level education, and for both technologists and technicians who will have had some undergraduate-level education.

Private Sector: Environmental engineers will be employed in the private sector largely by either industrial companies or consulting firms, with a limited number employed by nonprofit research institutions. In the private sector, environmental engineers will most likely find employment in the following areas:

a. administrators of environmental programs, and consultants to management and engineering;

b. designers of pollution abatement facilities and control equipment;

c. environmental consultants in such areas as monitoring, modeling, and equipment design;

d. researchers and developers of new processes;

e. monitors of pollutants, operators of facilities, and construction specialists, and;

f. instructors and training specialists for industrial applications.

It has been estimated that 50 per cent of the professionals involved in environmental activities should attend at least one training event at a minimum of once every three to five years. The level of training will represent 150,000 man-week units each year through 1985 for the private sector.[3] Some states are even requiring continuing education as a means of maintaining certification as a registered professional engineer. Short course continuing education will become increasingly important in the future as a means of upgrading and maintaining current professional skills. There must be improved methods to ascertain the performance of participants in such short courses.

<u>Public Sector</u>: A summary of estimated professional personnel needs in the public sector is illustrated in Table 17.[4] Approximately 16,000 professional engineers may be needed to accommodate some of the foreseeable programs according to the trends projected in 1977. However, substantially greater numbers of engineers will be needed in the future than shown in the estimates for solid wastes. This need for additional environmental engineers has been created by the recent passage of the Resource Conservation and Recovery Act and Toxic Substances Control Act. These needs are roughly estimated as 1,500 to 3,000 professional and 5,000 to 10,000 total personnel by 1985 for solid waste management alone. The recent promulgation for acceptable hazardous waste disposal practices for past as well as present and future sites by the U.S. Environmental Protection Agency will create additional employment opportunity in both the public and private sectors.

The nation's need to convert to coal in attempting to resolve its energy problems will create an additional major market for environmental engineers in both the public and private sectors, largely because of the passage of the Power Plant and Industrial Fuel Use Act. In the public sector, environmental engineers will be needed by both environmental and energy agencies at both the Federal and State levels for assignments such as permit review, equipment design and certification, impact estimation, plus effluent and ambient monitoring. This increased manpower need will be especially felt in the air pollution area, where as many as 6,000 to 7,500 professionals and 30,000 to 40,000 total personnel will be required by 1985.

Federal employment patterns are difficult to quantify because of inherent decentralization of the needed information. However, as of March 1976, EPA employed 1,572 engineers which amounted to 15 per cent of its total full-time, white-collar work force (10,277). At the same time, 1,744 (17.0 per cent) physical and biological scientists were employed by EPA. Interestingly, of this total 10,277 employees, the engineering degree classification and numbers employed were as follows: sanitary (607), general (501), chemical (190), mechanical (135), civil (78) and other (61).[(5)] At about this time (1974) the degree level and percentage of all Federal engineers and scientists was as follows: Ph.D. (9.1), Master's (19.8), Professional (1.4), Bachelor's (62.6), and no degree (7.1).[(6)] It may be desirable to include environmental engineering as a degree classification by the EPA and other government agencies in the future.

TABLE 17. Projected 1985 Environmental Manpower Requirements for the Public Sector[(4)]

Category	Personnel: Total	Personnel: Professional
Wastewater	136,500	8,000[a]
Water Supply	198,000	6,600[b]
Safe Drinking Water Act	3,840	1,130[c]
Solid Waste	5,000	250[d]
Air Pollution	24,000	4,800

[a] Both government and private sectors
[b] Engineers only, excludes 450 scientists
[c] Based on an estimate of 5% engineers in total manpower pool
[d] Based on an estimate of 20% engineers in total manpower pool

Note that as of 1977, EPA scientists occupied 65 per cent of the "supergrade" (GS 16-18) positions as compared to only 5 per cent for engineers. At the middle management levels (GS 12-15), the mix was 32 per cent and 27 per cent, respectively for scientists and engineers. General administrative and clerical positions occupied about 38 per cent of the total positions at EPA.(7)

It should be of interest to environmental engineers that EPA, as of 1977, did not actively seek extensive advice from engineers. Engineers at that date provided only about 20 per cent of the consultant, expert, or advisory board membership. Environmental engineers should play a much more important role in policy decision-making in the future.

Financial Support: Financial support is necessary to keep these programs in Environmental and Sanitary Engineering viable. Enrollment trends have typically followed financial support levels. This support has traditionally occurred in the form of training grants from the Federal government from either the U.S. Public Health Service (former) or the U.S. Environmental Protection Agency (latter). The U.S. Environmental Protection Agency has recently adopted a concept of regional training centers to provide both graduate level training and short course continuing education in air pollution and water pollution.

A particularly important issue applies when there is financial support of environmental engineering programs by the Federal government. It is important to maintain program quality and consistency in light of change in Federal environmental legislation and regulation. It is necessary to maintain program and curriculum flexibility to accommodate these changes. However, under no circumstances should any Federal agency dictate curriculum, and no university should accept funds when the quality of an engineering program may be reduced as a result of accepting such funds with a mandated curriculum.

A particularly useful form of financial assistance to students in environmental engineering curricula involves the role of internship. The internship provides a means for the student to combine practical work experience with his/her education.

Some caution must be exerted in the conduct of internship programs. Financial support needs to be provided by the sponsor throughout the internship period. This problem cannot always be easily solved if industrial or consulting firms are sponsors unless there is a continuing work requirement, which would tend to hinder the student's progress. The requirement of the student working for the sponsor for a fixed period after completing his internship is another potential problem. Another need of the internship is to assure that the student becomes involved in a project which is suitable for an engineering report during the working phase.

Role of Professionalism

The cornerstone of any profession is a professional education. The art of guiding the development of a curriculum, the selection of students and the proficiency of the faculty must be the concern of the profession and those entrusted in the administration of engineering education. Engineering practitioners and educators have agreed that engineering education is indeed a professional endeavor and practice as an engineering educator is relevant experience worthy of recognition by registration. Associated with this notion is that of professional registration of faculty who teach "engineering" topics.

The question of registration of engineering faculty is of concern to those who teach in engineering programs, to those who are engaged in the practice of engineering and employ graduates of accredited engineering programs, and to all of those who administer academic endeavors. The concern ranges from one end of the spectrum, as commonly expressed as mandated registration for all faculty who teach engineering subjects, to the other end, whereby no professional quality controls, as commonly expressed in terms of professional registration, are required. Obviously, in a university environment, a workable solution may be somewhere between the two extremes and interpreted differently by various universities and professional groups.

The following recommendation regarding professional registration was developed by the Engineering College Council of the American Society of Engineering Education.[8]

"The following resolution is submitted to ECC for its consideration and adoption."

WHEREAS, The profession called engineering has its roots in engineering education;

WHEREAS, The development and maintenance of appropriate educational standards is probably the foremost responsibility of the engineering profession;

WHEREAS, Faculty who are engineers should maintain professional competence;

WHEREAS, There is a growing need to establish a "Professional" base to forestall the arbitrary assignment of engineering faculty into a nonprofessional pool, and;

WHEREAS, It is important that engineering programs of study continue to provide academic leadership and maintain a professional image;

NOW THEREFORE, BE IT RESOLVED, that ASEE strongly encourage those who teach engineering to seek professional engineering registration, subject to all applicable laws.

BE IT FURTHER RESOLVED, that ASEE strongly oppose efforts to mandate professional registration of <u>all</u> faculty who teach in Colleges/Schools of Engineering, whether by legislation, regulations, or accreditation.

FINALLY, BE IT FURTHER RESOLVED, that ASEE work with the various state boards of professional registration for engineers, the Engineering Societies, and all the various engineering organizations to make professional engineering registration of qualified engineering faculty more meaningful for both the academic and nonacademic practitioners of engineering."

<u>Specialty Degree Production</u>
There has been a proliferation of institutions and programs offering "engineering" education. As of December 1979, there were about 1,295 accreditated degree programs provided by 239 institutions. This number represents almost a 50 per cent increase in the number of engineering programs in the United States existing in 1940.

The overall number of degrees conferred in Environmental and Sanitary Engineering as compared with other areas of engineering is very small. The question is how an institution can sustain a cost-effective degree program, in light of the fact that there were only 517 Masters and 36 Doctorates, graduated in Environmental and Sanitary Engineering in the United States during 1977-1978. A breakdown of degrees awarded in Environmental and Sanitary Engineering during 1977 and 1978 are shown in Table 18.(9, 10) According to the Engineering Manpower Commission, engineering degrees awarded at all U.S. schools 1977-78 were: 40,091 B.S., 15,736 M.S., and 2,573 Ph.D.

TABLE 18. Degrees Awarded in Environmental Engineering during 1977 and 1978.(9, 10)

Degree Awarded	Gender of Recipient	Number of Degrees Awarded: Environmental Engineering	Total Engineering Civil	Per Cent of Total
Bachelor	Male	261	7,276	3.6
	Female	48	2,225	2.2
	TOTAL	309	9,501	3.3
Master	Male	453	2,131	21.3
	Female	64	262	24.4
	TOTAL	517	2,393	21.6
Doctoral	Male	32	--	--
	Female	4	--	--
	TOTAL	36	284	13.0
TOTAL	Male	746	--	--
	Female	116	--	--
	TOTAL	862		

After two or three decades of major increases in output of graduates in Environmental and Sanitary engineering, the trend has been reversed. Unfortunately, there has been a national decline in U.S. citizens who elect to go to graduate school because of the favorable engineering employment market. Also, the EPA, appears to have forgotten why the government originally encouraged specialized programs in environmental engineering education.

As one Washington lawyer indicated, almost anyone can do a study as long as a regulation specifies a number. The private sector, while hurting in trained manpower, pays whatever the market place requires and thus may be able to survive the crunch, as compared with the public sector. The result will be major shortages of qualified personnel in the public sector, particularly for state and local environmental agencies.

Curricula

Curricula dealing with Environmental Engineering have been established by many educational units in the past.

In the past, one of the distinguishing features of Sanitary Engineering was that it had its philosophical roots in public health and a deep sense of duty and service. It is often forgotten that many of the early colleges of engineering offered B.S. degrees in Civil and Sanitary Engineering or Sanitary Engineering. Also, some of the early degree programs in Chemical and Mechanical Engineering had what amounted to strong options in Sanitary Engineering.

Background: A broader concept of environmental engineering evolved as the public health issues became more complex. Because of this need, advanced-level degree programs in Sanitary Engineering began to blossom during the 40's and 50's. During the 60's and 70's there was a re-emergence of the B.S. in Sanitary Engineering.

As the emphasis has shifted in the U.S. from rural and municipal sanitation, vector-borne disease control, and general public health, there has been a shift in the basic course requirements. For example, earlier course requirements included a course in vector-borne disease control and bacteriology. Today, this concern with physiological environmental agents has led to a concern for chemical environmental agents.

As the body of knowledge surrounding Environmental and Sanitary Engineering advanced, the role of foundation science courses became more fully defined. During the last decade, sanitary chemistry in some programs moved from courses in stoichiometry to include concepts such as homogenous solution chemistry, surface chemistry, and chemical kinetics as applied to diluteaqueous systems. Similarly, environmentally oriented biology and microbiology courses evolved into courses that stressed more of the ecological and biochemical concepts. The sophistication of computer and evolution of mathematical and computer-aided modeling techniques provided methodology for obtaining meaningful approximations to many vexing and complicated environmental problems.

Chemically-related environmental problems have caused increasing concern in recent years in terms of not only water pollution control, but also air pollution control and solid waste management. The complex problems of photochemical air pollution, and hazardous and toxic chemical waste disposal are sophisticated chemically-related environmental problems in nature which transcend the previous public health-related approach. Pollutant interactions and transport between the respective land, air, and water phases with associated transformations is an area of environmental engineering only now beginning to be appreciated in terms of its complexity and implications.

Foundation Sciences: The question of foundation sciences in environmental engineering curricula is an especially important one in establihsing professional competence and proficiency. Environmental engineering specializing in water supply water quality, or water pollution control must have a strong background in both the physical and life sciences. Similarly, environmental engineers specializing in air pollution control must have a strong background in physical sciences, including meteorology. Basic foundation science needs in solid waste engineering are not as well-defined as in water pollution and air pollution. It would be important for the environmental engineer specializing in solid waste management to become knowledgeable in several life and physical sciences.

Today, the spectrum of environmental concerns is so great that subspecialties in courses of study may actually be desired, but such specialization within a university setting must take place only when quality course offerings can be provided. Now, given the fact that specialization exists in the work environs, when and how does the educational machinery factor the necessary coursework into a beneficial degree program? Also, how does the profession monitor itself to assure both sufficient quantity and quality of its degree recipients?

Program Objectives:
The first question to be resolved regarding curricula is to establish the program objectives. The types of program options in environmental engineering programs might be summarized as follows:

(a) Two-year technician training program;

(b) Four-year technology degree program;

(c) Four- to five-year bachelor's degree in engineering;

(d) One- to two-year master's degree in engineering; and

(e) Three- to four-year doctor's degree in engineering.

Assuming that the basic degree structure will not change appreciably during the next few years, one may logically discuss curricula in terms of a four-year undergraduate degree, a one- to two-year Master's-level degree and a three- to four-year Ph.D.-level degree.

It is also important to define what is meant by curricular balance. The first question is one of balance between undergraduate and graduate degree programs. Questions of balance between theory and practice, and basic sciences relative to engineering design and synthesis must be weighed. The program balance between air pollution, water pollution, solid wastes, toxic substances and other topics must be delineated. Balance between research and course work must be appropriate for both students and faculty.

The role of research and independent study is important in the definition of and implementation of curricular balance objectives. Research and independent study in environmental engineering curricula is of least importance at the undergraduate level, and of considerable importance in doctoral programs. Research and independent study allows the student to investigate a particular topic in greater detail than might otherwise be possible in an organized formal course.

This research or independent study might involve preparing a term paper for a class at the undergraduate level. Research or independent study at the Master's level might involve a research paper for a special projects course, plus an experimental or computational thesis prepared under the close supervision of a professor. Research at the doctoral level in environmental engineering curricula would involve the initiation and conduct of a major research project of significant original merit and contribution by the student with a minimum of supervision by his major professor.

Undergraduate Environmental Engineering Curricula

Many colleges have undergraduate options or elective minors in environmental engineering. Approximately 15 to 20 colleges in the United States offer undergraduate environmental engineering degree programs at the present time. Defending the merits of an undergraduate degree in environmental engineering is beyond the scope of the present position of this paper.

Master's Level Curricula

Graduate level education in environmental engineering presents an interesting academic problem in specialty education. While there is a logical requirement for a basic requirement if the word engineering is part of the degree title, there is also a logical requirement for permitting students to select their graduate program on the basis of potential job specialization. Furthermore, since no single institution is likely to have the resources to accommodate all specialities with quality programs, it is imperative for institutions to maximize the quality of their course offerings by assessing the competence of their professoriate. A listing of future specialization might include subsets of the program identification as follows:

1. Air Resources Management

2. Water and Waste-Water Systems

3. Water Resources Management

4. Residual Waste Management

5. Environmental and Public Affairs Planning

6. Public Health Engineering

7. Stream and Estuarine Management

8. Radiological Health and Health Physics

Each of these specialty areas could support engineering job responsibilities in the following areas:

1. Program and project planning;

2. Data collection and evaluation, and project characterization;

3. Alternative evaluations, abatement consideration, economics, environmental quality, risk assessment, funding and project management;

4. Facilities design, construction, operation and project management;

5. Research and development;

6. Training, and;

7. Administration, policy development and implementation.

To enhance the likelihood of success of a student selecting any one of the environmental engineering specialties, it is necessary to understand the special requirements and options:

1. Basic engineering degree or minimum ECPD/ABET requirements;

2. Engineering - air, water, wastewater, and solid waste treatment; problem characterization; alternative design and evaluations and project management;

3. Engineering - systems engineering and modeling, unit operations and process evaluation, transport phenomenon, mass transfer, kinetics, numerical analysis and statistics; and operations research;

4. Basic Sciences - additional studies in at least one of the following:

   (a) Chemistry - organic, physical, inorganic and surface;

   (b) Microbiology - cellular processes and kinetics, disease transmission and biochemistry;

   (c) Ecology - material balances, energy flow, growth kinetics, food chains, tolerance limits;

   (d) Mathematics, and;

5. Public Affairs - public policy and decision-making processes, governmental processes, and American economic system.

The degree of specialization is a matter of personal choice for the student and generally the academic program is dictated by the availability of qualified faculty. The marketplace is not well enough defined in all of these areas to set forth much more than general specifications.

Faculty have a most severe responsibility to guide students through a course of study that will be beneficial throughout a working lifetime. A smorgasbord of elementary courses without engineering depth and selected supporting topics of sufficient depth is a sure way to relegate a student into the role of a technician.

Master's level degrees in Environmental Engineering can be either Master of Science or Master of Engineering. Either degree in Environmental Engineering must be a truly professional degree, and must require a balanced curriculum involving about 1.5 to 2 years of study beyond the minimum requirements recommended by ECPD/ABET. A detailed analysis of ECPD/ABET requirements are presented in Appendix A.

The professional degree ought to provide the graduate with an enhanced ability to listen, speak, read, write, calculate, think, reason, and solve problems. The resulting professional engineer must be innovative, capable of adopting to changing social and technological conditions, creative in designing and management, professionally responsible, and with high ethical standards, and social conscience.

The "Guide for Environmental Engineering Visitors on ECPD Accreditation Teams" has the following comments relative to graduate curriculum:

> At the master's level the environmental engineering student should acquire both a concept of breadth and understanding of the entire environmental engineering domain and also achieve an in-depth competency in the particular area of specialization. One must be well versed in the basic sciences and mathematics fundamentals and be capable of applying these fundamentals to the solution of complex environmental engineering problems. As an engineer one must be competent to design systems, facilities, and processes necessary for environmental control measures.

The diversity of the specialized fields in environmental engineering dictates that separate curriculum models be identified. The general ECPD/ABET criteria for advanced-level accreditation specifies that the curricular content of the program includes:

1. The equivalent of one additional year of study above that required for a basic level program. This additional year of study would include by way of course work, thesis, research, or special projects at least one-third year of engineering design and one-third year of one or a combination of the subjects of advanced mathematics, basic sciences, or engineering design arranged so as to

meet the objectives of a particular program of the institution or to complete a meaningful individual course of study. The additional year of study must include a considerable amount of material and treatment at an advanced-level not normally associated with the basic level.

2. Advanced degree students may be exempted from the requirement of additional humanities and social sciences if the school can demonstrate that the student concerned has received equivalent education in this area before undertaking the advanced program.

It should be noted that strong emphasis is placed on the engineering design component, and the specified one-third year of design at the graduate level should be clearly identified in the syllabi of courses required in the curriculum. Cost effectiveness of environmental control systems should be included in design considerations.

Specific programs for each specialty area will vary considerably in their course content, and no one suggested program should be judged as the exact model. Subject matter only should be specified, with the specific mix of courses left to the discretion of the institution and with the overriding control vested in the ECPD/ABET criteria as quoted above. The following suggested master's programs in the four specialty areas as indicated below are to be treated as guidelines only in reviewing the components of a particular program:

1. <u>Air Quality Engineering - Master's Program</u>

Fundamentals of air pollution: air pollution dynamics, source factors
Atmospheric sampling and analysis: chemistry of pollutants, sampling and analysis, photochemistry
Meteorology: properties and dynamics of the atmosphere, atmospheric transport and diffusion
Physics: aerosol science and technology, including optical properties of atmospheric aerosols
Air pollution control systems, air pollution management
Applied mathematics: advanced statistics, mathematical models
Biological aspects of air pollution: cell and human biology, effects on vegetation, animals and humans, air microbiology
Thesis options

2. <u>Industrial Hygiene Engineering - Master's Program</u>

Applied mathematics: biostatistics, mathematical modeling
Occupational health: audiology, toxicology, radiology, physiology, public health, epidemiology, and safety engineering
Thesis option

3. <u>Solid Wastes Management - Master's Program</u>

Resource recovery: conservation and reuse, recycle economics
Microbiology of water, air and soil: applications to environmental pollution control
Analytical analysis: (physical, chemical, and biological) of water, wastewater, air, and solid wastes
Solid wastes control and management: characterization, production, storage, collection and transport of solid wastes; alternative disposal methods, design principles and environmental impact; economics of waste management
Combustion engineering: combustion fundamentals, incinerator design
Thesis option

4. <u>Water Quality Engineering - Master's Program</u>

General water quality and analysis: sanitary analysis, applied organic and physical chemistry, applied microbiology
Applied mathematics: mathematical models environmental statistics, optimization techniques
Unit operations and design: design of treatment facilities; chemical, physical, and biological systems
Water resources systems analysis, simulation analysis
Thesis option

Ultimately, the personal aspects of engineering might develop and evolve from:

1. Practical experience;

2. Rational approaches;

3. Analytical abilities;

4. Synthesis/Design capabilities;

5. Awareness and response to human needs;

6. Communication/Business skills;

7. Culture awareness; and

8. Goals/Creed/Loyalty

In view of the above, a typical Master's degree in Environmental Engineering might logically include the following:

1. Basic ECPD/ABET minimum requirements for undergraduate engineering degree;

2. Thesis - research project on a suitable topic;

3. Graduate-level of a suitable nature to meet the student's needs in a specific program area with sufficient breadth, depth, and flexibility.

Doctor's Level Curricula

The doctoral degree in Environmental Engineering (whether Ph.D. or Dr. of Engineering) contains the word engineering and therefore must also rigorously conform to the highest standards of engineering education. Under no circumstances can an engineering degree be awarded through a veil of "undergraduate" science courses. Consequently, the minimum science and engineering requirements are those that apply to the combination of ECPD/ABET and research requirements.

Programs for the Ph.D. in Environmental Engineering should stress scholarly research assisted by coursework. The Ph.D. program should be tailored to the student's individual interests and needs in his area of interest. The supervising faculty member and the student should have a close personal working relationship to facilitate successful completion of the degree program with a high quality dissertation on original research.

The student's course program should emphasize his specific area of interest in Environmental Engineering to assist his dissertation effort. The student should also take at least one course in each of the other areas of Environmental Engineering to assure sufficient breadth. It would be beneficial for the student to have at least one course related to the social and economic consequences of environmental engineering in his degree program.

Continuing Engineering Education

Today, the practicing world of engineering has clearly recognized the need of the professional engineer to participate in continuing education. According to the conclusions reached at the 1972 FEANI/UNESCO Helsinki Seminar on "Continuing Education of the Engineer."(11)

> The first need of all is based on the role of the engineer in society to improve the conditions in which his fellow citizens live, by meeting the increasing demand for food, housing, communication, and all other services. Thus, to meet his obligations to perform efficiently and safely, the engineer has need to keep informed of technical developments . . . In addition, the practicing engineer may find it necessary to change his job at some time either because of developments in his own working situation or because there is no longer a demand for his special abilities.

Continuing Engineering Education (CEE) has been created to meet these educational needs of our profession. Historically, CEE programs have emphasized the "Specific enhancement of an individual's competence rather than the attainment of an additional academic degree!" The Committee on Goals of Engineering Education clarified the four principal purposes of continuing education as follows:(12)

(a) Upgrading, in which a person pursues an articulated formal program of study to raise the student's level of education;

(b) Updating, in which a person who has received a bachelor's degree ten years ago may take course work to make his formal education comparable to that of a person receiving a bachelor's degree today;

(c) Diversifying, in which a person educated in one field may seek to obtain some formal education in another field but not necessarily at a higher degree level, and;

(d) Broadening, in which a person expands his/her perspectives by including areas such as financial, political, and social factors, but again without necessarily raising the academic level of the education.

Continuing Engineering Education currently takes many forms. Continuing Engineering Education not only includes traditional education formats of conferences, single lectures and lecture series, but also includes standard short courses, workshops, symposia, seminars, and the recent generation of transactional analysis activities. These latter groups involve interpersonal-relations activities with role playing case studies, games, and other human interaction simulations.

Within the past five years educators and engineers have begun to exploit the newly available communication/logic technology for educational purposes. Through these efforts CEE is now being provided to the practicing engineer via television with talkback, electrowriters and blackboard-by-wire, audio and video cassettes, programmed instruction, computer-based education and electronic simulators. Many of these give immediate feedback and continuous student-proctor interaction. This instruction is increasingly available at times and locations convenient to the student.

The ground rules for Continuing Engineering Education are as follows:

1. CEE activities should be conducted only in those areas where a clearly demonstrated need for professional practitioners exists at the time of offering:

2. CEE activities are conducted which will make a difference to the profession, and do not merely duplicate an existing activity;

3. CEE programs are selected which involve the unique expertise of the university's faculty, and;

4. CEE programs are set, with setting new standards of learning excellence.

All offerings are regularly subjected to preview and review, plus feedback critique and recommendations for improvement.

Continuing Engineering Education activities in environmental engineering may be conducted in specific areas of specialization such as water pollution, water supply, air pollution, and solid wastes. These activities can be designed to serve practitioners employed by consulting firms, industries, and government agencies. The recent establishing of regional training centers by the

U.S. Environmental Protection Agency in air pollution control and more recently, in water pollution control will help in the conduct of Continuing Engineering Education activities in environmental engineering.

Continuing Engineering Education activities help to maintain and expand contacts between university faculty with practitioners in the field. The results of Continuing Engineering Education activities are to provide a means for updating of faculty skills, develop new material inputs for lectures, stimulating new research ideas, and possible sponsorships that generate prospective student enrollments. All of these activities in conducting short courses and conferences as a part of Continuing Engineering Education develop environmental engineering teaching and research programs when kept in balance with other activites.

Conclusions

Curricular balance is an essential part of environmental engineering education. Curricular balance must be defined in terms of degree programs, subject matter, field of specialization and program emphasis. Curricular balance in environmental engineering education must be implemented to provide and maintain the highest quality degree standards for program graduates, serve potential employers in terms of technical skills, and yet serve the student's educational needs.

Program objectives might be developed for the specific degree programs in terms of technician training, undergraduate degree programs, and graduate programs at the Master's and Doctoral levels. Undergraduate degree programs in environmental engineering might be tailored to specific student needs, but normally could be incorporated as parts of other engineering departments. It will be essential to provide suitably rigorous graduate programs with a proper balance between basic sciences and engineering design and synthesis to meet ECPD/ABET accreditation requirements, and also provide marketable degrees.

Degree program specialization at the Master's level might be in a specific field of environmental engineering such as water pollution, air pollution or solid wastes. Curriculum course balance should be provided to serve the needs of the specific fields of study in environmental engineering. Doctoral programs should emphasize preparation for scholarly research and advanced-level engineering with a sufficient degree of breadth and depth and the flexibility to serve individual student needs.

The need for environmental engineers will grow. Curricular balance must be provided in terms of both fundamental principles and engineering applications to allow development of solutions to environment problems which are technically, legally, and economically feasible.

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10. Anon., Unpublished Data, National Science Foundation, Status of 1977 Graduates in 1979, National Science Foundation, Washington, D.C. (1979).

11. Anon., Conclusions and Recommendations, 1972 FEANI/UNESCO Seminar on Continuing Education for Engineers, Helsinki, Finland (August 1972).

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Appendix A

The "Guide for Environmental Engineering Visitors on ECPD Accreditation Teams" as developed by a Joint Ad Hoc Committee of AAEE (Education Committee), ASCE (Committee on Curricula and Accreditation) and AEEP provides the following comments:[1a]

> Environmental engineers require a broad background in the basic sciences and engineering sciences. They should have preparation in chemical, physical, and biological sciences. In addition to the mathematics normally required of engineering through differential equations, the curriculum should include course work in statistics.
>
> The engineering sciences in the curriculum should be those needed by the student preparing for the diverse fields of environmental engineering. Applicable engineering sciences include: dynamics, thermodynamics, solid and fluid mechanics, electrical circuits and control systems, and transport phenomena.

Little specialization is possible or suggested at the undergraduate level. It is recommended that the curriculum provide an awareness of the environmental engineering principles applicable to all fields. Examples are courses that relate to human health, ecology and the environment. At least three areas of environmental engineering should be provided, such as:

Air Pollution Control Engineering
Water Quality Engineering
Solid Wastes Engineering
Environmental Health Engineering

Electives that supplement these areas include: geology, hydrology, meteorology, atomic physics, urban and regional planning and management, chemistry, biology, oceanography, economics, and geography. The electives offered should be appropriate to the environmental engineering program.

The general ECPD/ABET criteria for basic level accreditation which must be met by any engineering program are:

Basic Sciences (including 1/2 yr. math beyond trigonometry)	1 year
Engineering Science	1 year
Engineering Design and Systems	1/2 year
Humanities and Social Science	1/2 year

An example of a suitable curriculum for an undergraduate environmental engineering program is shown in Table 19. The program includes courses in mathematics, engineering science, engineering design and systems plus humanities and social sciences. The above requirements coincide with suggestions by ECPD/ABET for accreditation of undergraduate environmental engineering programs.

TABLE 19. Suggested ECPD/ABET Requirements for an Undergraduate Program in Environmental Engineering[1a]

ECPD Requirement	Suggested Curriculum
A. 1 year math and basic science 1/2 year of mathematics beyond trigonometry	Chemistry and biol. science, of which at least 8 sem. hrs. should be chemistry and 4 sem. hrs. biology Math, incl. diff. equations and applied statistics Physics
B. 1 year engineering science	Thermodynamics, fluid mechanics, elec. circuits and systems, statics, mechanics, dynamics, engr. geology, materials, two engr. science electives
C. 1/2 year engineering design and systems	Unit operation and processes in environmental engr., environ. systems anal., three electives in environ. engr.
D. 1/2 year humanities and social science	See ECPD/ABET criteria statements

If a university elects to offer an undergraduate degree in environmental engineering, it surely ought to do so with the full intention of meeting the minimum ECPD/ABET criteria for accreditation. As should be well known, ECPD/ABET guidelines do not specify detailed course areas such as physics, etc. However, ECPD/ABET criteria specify that overall curriculum in mathematics, the basic sciences, the engineering sciences and engineering design should provide an integrated educational experience directed toward the development of the ability to apply pertinent knowledge to the identification and solution of practical problems in the designated areas of engineering specialization. The central theme of these minimum criteria is that there will be a basis of substantive science and that there will be a design and synthesis component in each engineering curriculum. These guidelines are shown in Table 20.

TABLE 20. Guidelines for Undergraduate Environmental Engineering Curricula[2a]

	Subject Matter	ECPD (years)	AAEE (years)
1.	Humanities and Social Sciences	1/2	1/2
2.	Math, Science and Engineering	2 1/2	3
	(a) Math (beyond trig.)	1/2	1/2
	(b) Basic Sciences	1/2	1
	Physics	ns	1/4
	Chemistry	ns	1/2
	Biological Sciences	ns	1/4
	(c) Engineering Sciences	1	1
	General Eng. Science	ns	1/2
	Environmental Eng. Science	ns	1/2
	(d) Design, Synthesis and Systems	1/2	1/2
3.	Electives	ns	1/2

ns = not specified

The American Academy of Environmental Engineers (AAEE) guidelines provide specific recommendations regarding undergraduate curricula. Similarly, a joint committee of the AAEE Education Committee and the Education Committee Association of Environmental Engineering Professors (AEEP) has prepared more detailed guidelines to assist ECPD/ABET teams in the review of undergraduate environmental engineering programs. The distribution of coursework in environmental degree programs is presented in Table 21.

TABLE 21. Distribution of Coursework in Environmental Engineering (Undergraduate)[3a]

Subject Matter	Average (%)	Minimum (%)	Maximum (%)
Humanities & Social Sciences	17.2	10.9	32.0
Mathematics	12.4	10.7	15.1
Computer Science	1.0	0.0	2.1
Chemistry	8.2	3.1	14.3
Physics	6.7	3.1	8.5
Biology	2.6	0.0	10.1
Engineering Science	26.4	14.5	44.8
Environmental Engineering	14.6	8.9	25.7
Electives	9.5	4.1	20.6

Advantages of the undergraduate program in environmental engineering were listed during the Third National Conference on Environmental Engineering Education.[3a] The overall assessment of undergraduate program development is still sketchy. The student and academic units offering a Bachelor's degree in Environmental Engineering have a responsibility to provide a degree that is marketable and does not relegate the holder into a sanitarian, technician, or technologist role.

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1a. Anon., "Guide for Environmental Engineering Visitors on ECPD Accreditation Teams," Prepared by Ad Hoc Committee AAEE, ASCE, and AEEP (February 1979).

2a. Patterson, J. W. and Male, J. W., "Baccalaureate Programs in Environmental Engineering," Engineering Education, (Vol. 4), pp. 319-325 (January 1978).

3a. Purdom, P. W., "Is Undergraduate Environmental Engineering Education Desirable?" Journal of Environmental Engineering Division, American Society of Civil Engineering, 102, EE2 (April 1976).

DISCUSSION GROUP REPORT

CURRICULAR BALANCE IN ENVIRONMENTAL ENGINEERING EDUCATION

1. ISSUE: What background courses should be required for persons from other than engineering undergraduate projors enrolled in graduate level programs in environmental engineering?
CONCLUSION: A balanced curriculum involving the minimum requirements of CPD/ABET should generally be included as the background courses for the Master's level in environmental engineering curricula. Considerable variations in these background requirements may occur between individual students depending upon their respective undergraduate degree programs, the degree programs offered by the individual universities and the educational goals of the student.
RECOMMENDATION: Considerable additional discussion will be needed on this issue in the future. This topic should be fully debated by the full meeting participants, with the need for follow-on discussions.

2. ISSUE: What areas of specialization should be defined in environmental engineering curricula?
CONCLUSION: The titles of the major areas of specialization in environmental engineering should read as follows: 1) Air Quality; 2) Occupational Health; 3) Solid Wastes; 4) Water Quality.
RECOMMENDATION: Other areas of specialization may need to be developed in the future based on changing needs in environmental engineering curricula.

3. ISSUE: Should persons teaching environmental engineering be required to obtain registration as a professional engineer?
CONCLUSION: Persons teaching environmental engineering courses should be encouraged to become registered as professional engineers wherever beneficial or applicable. Persons should not be required to obtain registration as a professional engineer in order to maintain employment for teaching of environmental engineering courses because of the very diverse nature of the field. Mandatory registration by legislation, regulation or accreditation is opposed.

RECOMMENDATION: Careful monitoring of requirements for professional engineering registration should be undertaken for each state. The recommendations of the Engineering College Council of the American Society of Engineering Education should be endorsed. (See Conference Position Paper.)

4. ISSUE: What are the main future needs for continuing education activites in environmental engineering?
CONCLUSION: Continuing education activities in environmental engineering should be much more strongly emphasized in the future to serve future professional needs. Quality control guidelines for continuing education in environmental engineering should be developed. High priority should be given to content and currentness of course offerings.
RECOMMENDATION: More emphasis needs to be placed on continuing engineering education in the overall environmental engineering curricula balance picture.

5. ISSUE: Should graduate level programs in environmental engineering be accredited by ECPD/ABET?
CONCLUSION: Those environmental engineering programs at the graduate level who desire to do so should be encouraged to seek accreditation from ECPD/ABET?
RECOMMENDATION: The decision to seek accreditation of graduate level programs in environmental engineering should be left to the individual universities.

6. ISSUE: How should undergraduate and graduate curricula in environmental engineering be modified to reflect changes in manpower needs?
CONCLUSION: Attention should be given to curriculum dynamics for meeting changing requirements for environmental manpower within the capabilities and expertise of the individual university faculty. There should not be sudden or rapid changes based on Federal laws or regulations which would result in curriculum disruptions quality reduction of faculty overextension.
RECOMMENDATION: Additional attention should be given to curriculum dynamics to reflect changing environmental manpower needs for the future meetings. The questions of manpower need projection employment market development, faculty recruiting and updating, course modification and changes, plus funding requirements all need to be included as a part of the discussion.

PLENARY SESSION ACTIONS

CURRICULAR BALANCE IN ENVIRONMENTAL ENGINEERING EDUCATION

The Discussion Group Report was presented to the Plenary Session for acceptance, by Hal Cooper. The individual items of the report were brought to the floor in sequence for approval as summarized below:

Item 1 — This item was declared out of order by the Chairman and thus was not brought to a vote.

Item 2 — Hal Cooper moved for acceptance of the Item. Don Aulenbach seconded the motion.

Discussion - Amendments. Dan Okun moved and Bruce Hanes seconded to change Occupational Health to Environmental Health. The amendment passed.

An additional amendment to change water quality to water resources was defeated. Neither proposor or seconder was identified (secretary was on facilities leave).

Gary Heinke then moved that water resources be added to the wording as area of specialization No. 5. Bruce Hanes seconded the motion. The amendment passed unanimously.

Vote on the amended motion: The motion failed 14 to 18.

Item 3 — Hal Cooper moved for acceptance of the item and Harold Bevis seconded. The motion passed without opposition.

Item 4 — Hal Cooper moved for acceptance and Bruce Hanes seconded the motion. The motion passed without opposition.

Item 5 — Hal Cooper moved for acceptance and Jan Scherfig seconded the motion. The motion passed without opposition.

Item 6 — Hal Cooper moved for acceptance and Bruce Hanes seconded the motion. The motion passed without opposition.

A group chaired by Steve Shelton prepared a minority report intended to be submitted at the Plenary Session.

Steve Shelton indicated that he would, in lieu of the minority report, submit an editorial insertion to the committee report. By agreement with the chair, this minority report was not brought to a vote at the Plenary Session but is presented below since the ideas expressed in this minority report appeared to represent the position of several discussion group participants.

Minority Report

The discussion group report entitled "Curriculum Balance in Environmental Engineering," by reference to ECPD/ABET as the basis for advanced studies in environmental engineering, is arbitrary and may preclude certain otherwise well qualified individuals from pursuing a Master's degree in environmental engineering and since Ph.D. degrees are considered research degrees, the position paper entitled "Curriculum Balance in Environmental Engineering" be modified as follows:

I. Delete the section entitled "Master's Level Curricula" and replace it with the following:

Masters Environmental Engineering Curricula

Graduate level education in environmental engineering presents the unique opportunity to synthesize traditional engineering with applied science to produce graduates capable of addressing complex multidisciplinary environmental issues. To assure diversity and product excellence from masters programs in environmental engineering, entering students should:

1. Have an undergraduate degree in engineering or applied science. Students who have not prepared specifically for a Masters of Enviromental Engineering should be required to augment their backgrounds in applied science or engineering as necessary to comprehend adequately and build upon the principles essential to instruction in a master's program.

2, Have a foundation in applied science and engineering, including:

   a. chemistry

   b. biology

   c. mathematics

   d. physics

   e. engineering applications of the above including quantitative problem solving

3. Have a foundation in social sciences such as economics and political sciences.

The degree of specialization is a matter of personal choice for the student and generally the academic program is dictated by the availability of qualified faculty. The marketplace is not well enough defined in all these areas to set forth much more than general specifications.

Faculty have a most severe responsibility to guide students through a course of study that will be beneficial throughout a working lifetime. A smorgasbord of elementary courses without engineering depth and selected supporting topics of sufficient depth is a sure way to relegate a student into the role of a technician.

The Masters degree ought to provide the graduate with an enhanced ability to listen, speak, read, write, calculate, think, reason, and solve problems. The resulting engineer must be innovative, capable of adopting to changing social and technological conditions, creative in design and management, professionally responsible, and with high ethical standards, and social conscience.

Specific programs for each specialty area will vary considerably in their course content, and no one suggested program should be judged as the exact model. Subject matter only should be specified, with the specific mix of courses left to the discretion of the institution. The following suggested engineering master's programs in four specialty areas indicated below are to be treated as guidelines only in reviewing the components of a particular program.

1. <u>Air Quality</u>

   Fundamentals of air pollution: air pollution dynamics, source factors

   Atmospheric sampling and analysis: chemistry of pollutants, sampling and analysis, photochemistry

   Meteorology: properties and dynamics of the atmosphere, atmospheric transport and diffusion

Physics: aerosol science and technology, including optical properties of atmospheric aerosols

Air pollution control systems, air pollution management

Applied mathematics: advanced statistics, mathematical models

Biological aspects of air pollution: cell and human biology, effects on vegetation, animals and humans, air microbiology

Thesis option

2. Industrial Hygiene

Applied mathematics: biostatistics, mathematical modeling

Occupational health: audiology, toxicology, radiology, physiology, public health, epidemiology, and safety engineering

Thesis option

3. Solid Wastes

Resource recovery: conservation and reuse, recycle economics

Microbiology of water, air, and soil: applications to environmental pollution control

Solid wastes control and management: characterization, production, storage, collection and transport of solid wastes; alternative disposal methods, design principles and environmental impact; economics of waste management

Combustion engineering: combustion fundamentals, incinerator design

Thesis option

4. Water Quality

General water quality and analysis: sanitary analysis, applied organic and physical chemistry, applied microbiology

Applied mathematics: mathematical models, environmental statistics, optimization techniques

Unit operations and design: design of treatment facilities; chemical, physical, and biological systems

Water resources systems analysis, simulation analysis

Thesis option

In view of the above, a typical Master's degree in Environmental Engineering might logically include the following:

1. Graduate level coursework of a suitable nature to meet the student's needs in a specific program area with sufficient breadth, depth, and flexibility;

2. Thesis or research project on a suitable topic.

II. Delete the section entitled "Doctor's Level Curricula" and replace it with the following:

Ph.D. Environmental Engineering Curricula

Programs for the Ph.D. conducted in the area of Environmental Engineering should stress scholarly research assisted by coursework. The Ph.D. program should be tailored to the student's individual interests and needs in his area of interest. The supervising faculty member and the student should have a close personal working relationship to facilitate successful completion of the degree program with a high quality dissertation on original research.

The student's course program should emphasize his specific area of interest in Environmental Engineering to assist his dissertation effort. The student should also become acquainted with the other areas of Environmental Engineering to assure sufficient breadth. It would be beneficial for the student to become acquainted with the social and economic consequences of environmental problems.

III. Appoint a committee to develop a professional terminal degree Curricula statement.

POSITION PAPER

RELATIONSHIP OF BACCALAUREATE TO GRADUATE ENVIRONMENTAL ENGINEERING EDUCATION

Donald B. Aulenbach, Co-chairman
James P. Heaney, Co-chairman
James Alleman
Barry A. Benedict
Michael D. LaGrega
Michael Semmens
William W. Shuster
Marty Wanielista

CONTENTS

A. PRESENT BACCALAUREATE EDUCATION IN ENVIRONMENTAL ENGINEERING

The future of an educational discipline remains with the social acceptance of its product. After two decades of undergraduate environmental engineering education bachelor's degree production continues, but is low relative to other disciplines. The baccalaureate programs are in existence, graduates are gaining employment, but have the needs of society been examined, defined, and satisfied? The purpose of this paper is to introduce ideas to enhance the educational efforts related to social needs for environmental engineers.

1. Existing degree programs

In the Register of Undergraduate Programs in Environmental Engineering(1) 22 undergraduate programs which may be considered environmental engineering programs were identified. There are numerous other programs which have options or just a few courses in environmental engineering, but these 22 schools were considered to be complete programs in environmental engineering. The existing degree programs were evaluated by Aulenbach.(2)

a. <u>Titles</u>
Although there is considerable diversity in the title designations used, 17 of the 22 schools in the Register include the word "environmental" in their title. Only one school still retains the title of "sanitary engineering," while 3 programs use the designation of "civil engineering." The remaining "non-enviromental" designation consists of "Water and Air Resources." There has been speculation that in light of the federal leadership in the field since the establishment of the EPA in 1970, a preponderance of federal, state and local agencies has been established containing the designation "environmental" and this trend is reflected in the designations chosen by academic programs in this field. Many schools,

however, feel that the designation of "engineering" is also essential to distinquish "professional" from "non-professional" programs. With the present public concern and large financing being invested in environmental programs, it is likely that even more educational, private and public agencies will adopt a title designating connections with environmental activities.

b. <u>Administration</u>

Nine schools indicated that their programs are located within the Civil Engineering department, while an additional school grants the degree through the department entitled "Civil Engineering and Environmental Science." The programs for degrees in environmental engineering can also be found associated with other engineering programs, these combinations include "Chemical and Environmental Engineering" and "Mechanical and Environmental Engineering." In two schools the program is included in the area of "Interdisciplinary Studies." Only four schools indicate that their programs are independent departments. One of these is entitled "Environmental and Water Resources Engineering," the others simply "Environmental Engineering." The remaining schools indicate that their program belongs to general catch-departments such as "Engineering Science," "Engineering Analysis" or just "Engineering."

The existence of only four independent departments can be attributed to two general causes. The first stems from the relative youth of the majority of these programs. Fifteen of the 22 schools included in the Register indicated the year their programs began. The oldest program dates back to 1963, while nearly half of those indicating dates were established five or less years ago. It should be noted, however, that many of these were born of long standing options in other fields, most notably civil engineering.

The second factor is the limited enrollment in the programs. Nineteen of the schools responded with enrollment and graduation data, although in four cases the programs are too new to have any graduates at all. In the 19 undergraduate programs there is a total of 851 students enrolled, and among the 15 schools graduating students, a total of 231 degrees are granted. These figures demonstrate no apparent need for individual departments solely for environmental engineering pursuits.

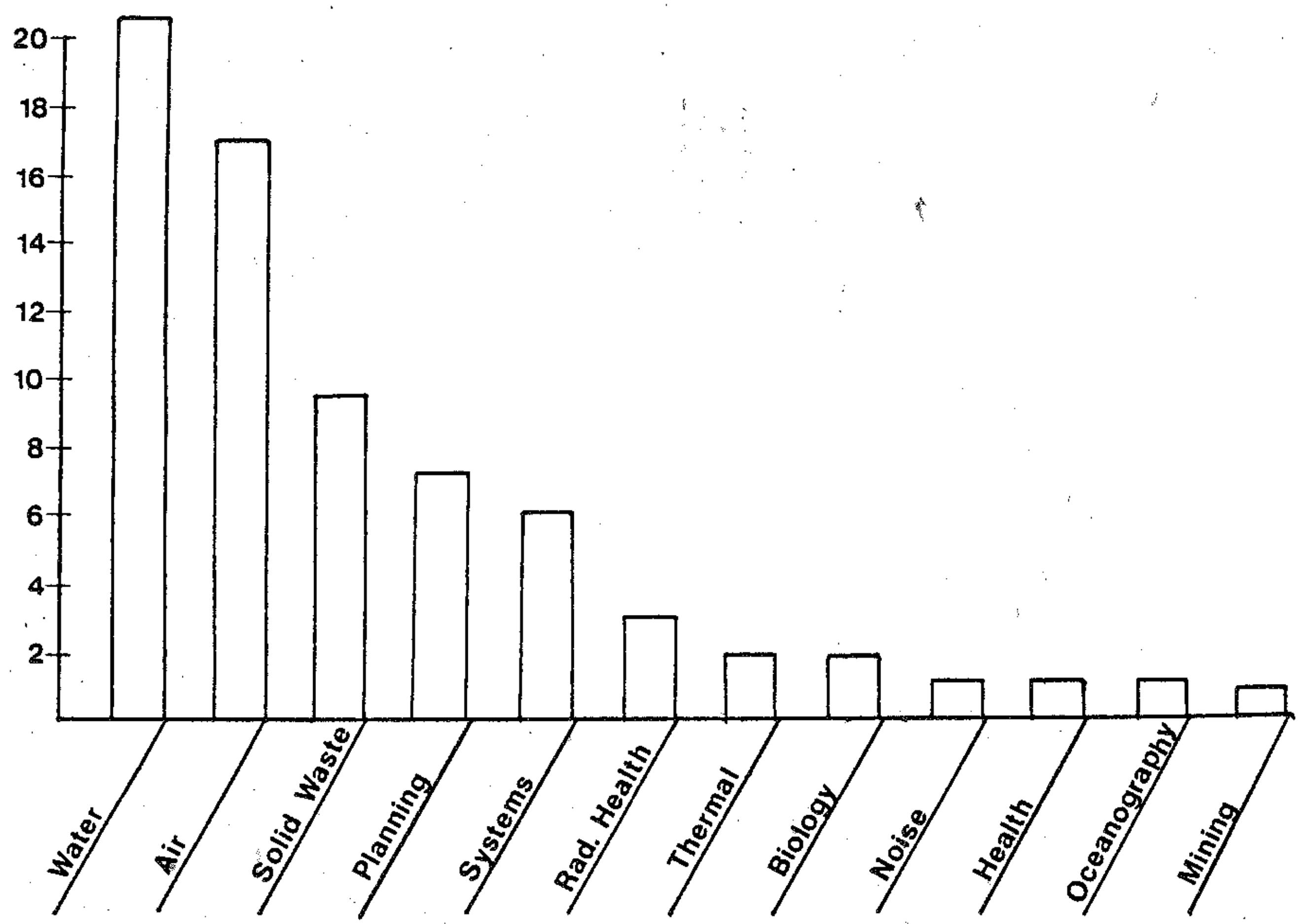
c. Courses

As all the schools included in the Register are either predominately engineering oriented institutions or schools of engineering located within a larger university system, the requirements of the first two general categories were fairly similar. These two groups form what most schools refer to as their "engineering core" or "pre-engineering" program. An average program of this type includes about 12-18 credit hours of free electives in the humanities or social sciences; within this H&SS requirement the two courses most frequently mentioned as necessary are "freshman English" and introductory economics. Most require four semesters of mathematics including at least two semesters of calculus and one semester of differential equations. Over half the responding schools now require at least one course in basic computer science. In the area of the general sciences, chemistry and physics are required at all the schools, while biology is required in only about a third (biology is cited as a required program course or prerequisite in nearly all the remaining schools). Required engineering courses usually named are mechanics, fluid mechanics, properties and strength of materials, thermodynamics, electrical circuits and a principles of engineering course.

Program prerequisites consist of those background courses not included in the engineering core. This area shows the greatest variety between the various orientations or, perhaps more important origins of the respective programs. Those programs which stemmed from an existing option within the civil engineering program tend to require more background in the civil engineering field, namely more structures and mechanics courses. Some schools show tendencies toward more advanced biology and chemistry courses, most common are such courses as microbiology, organic chemistry and physical chemistry. One school places a firm background in mechanical engineering in its program prerequisites.

The required program courses and available technical electives are difficult to analyze because of the wide differences in course designations. However, some trends are still definitive enough to note here. Courses dealing with the collection and treatment of water supplies and of waste waters, water resources, and basic unit operations and processes are required in each program. Reviewing both the required and optional courses, each school was evaluated to determine if there exists the possibility for a student, through selection of optional courses, to specialize in a particular field of environmental engineering. Some schools demonstrated enough variety and depth of available courses that as many as four options could be realized. A graphic display of these findings is shown in Figure 10. This indicates a surprising degree of diversification possible as early as the undergraduate level. It should be noted that the classification "water" includes both water and wastewater treatment and the broader concept of water resources. Also the "planning-management" classification could probably be combined with those programs in "systems analysis," making this new concept of planning and managing of the environment in a logical and systematic way nearly as widespread as the more traditional field of air pollution control.

FIGURE 10. Program Content



Other aspects of the programs are recorded under the area of degree requirements. These include possible projects or thesis, Pass/Fail options, availability of accelerated programs and normal time required for completion of degree. On the question of required projects, the schools are fairly evenly distributed. Of those responding, six indicate that students are required to participate in projects, seven show this as being an available option, while seven schools state no such option is open to students. The Pass/Fail option is available at 14 of 19 responding schools. Most schools place constraints on the number of courses the student can take under this option. In addition, many restrict the Pass/Fail designation to non-required, non-major courses. The schools all indicated that the program normally requires 4 years (32-36 months on campus), but most stated that it is possible to graduate in three years by including academic overloads and/or summer semesters.

2. Coursework

Environmental problems are complex requiring both broad and specific educational foundations. People with many educational backgrounds are employed by agencies involved with environmental activities. Environmental engineers will most likely have the broad educational background to recognize the interrelationships among complex problems (environmental impacts), and technical abilities to examine, define, and solve some specific aspects of the environmental problem. Recognition of the extent of the responsibilities is evident in the definition of environmental engineering[3]

> *that branch of engineering which is concerned with (a) the protection of human populations from the effects of adverse environmental factors; (b) the protection of environments, both local and global, from the potentially deleterious effects of human activities; and (c) the improvement of environmental quality for man's health and wellbeing.*

Using only parts (a), (b), and (c) of this definition, most disciplines can argue that they are somehow doing environmental protection, but as a branch of engineering, the number of people classified as environmental engineers decreases. Engineering programs specify course work for accreditation, thus, producing a person with defined talents.

Guidelines for accreditation have been developed by the Engineers' Council for Professional Development (ECPD)[4] and the American Academy of Environmental Engineers (AAEE).[5] These are illustrated in Table 22. The differences between the criteria are not significant. In some cases, part of the one year of electives and other course materials required by ECPD may be counted as basic science, making the guidelines closer to each other.

After consideration of these guidelines, the AAEE Education Committee with the Association of Environmental Engineering Professors (AEEP) Education Committee prepared a more detailed set of criteria.

TABLE 22. ECPD and AAEE Accreditation

Guidelines for Environmental Engineering Curricula

	Subject Matter	ECPD (%)	AAEE (%)
1.	Humanities & Social Science	12.5	12.5
2.	Mathematics (beyond trig and including Probability (Statistics))	12.5	12.5
3.	Basic Sciences	12.5	25.0
4.	Engineering Sciences	25.0	25.0
5.	Design, Synthesis & Systems	12.5	12.5
6.	Electives and Others	25.0	12.5
		100	100

Patterson[6], [7], reported on the average coursework from fifteen institutions offering undergraduate degree programs. Similar ECPD and AAEE subject matter areas are used for comparison in Table 23. There appear to be variations among the fifteen programs, as expected, but all appear to provide general science, mathematics, engineering science, and environmental engineering coursework.

TABLE 23. Average, Minimum, and Maximum Percentage Distribution of Coursework in Environmental Engineering[6]

	Subject Matter	Average %	Minimum %	Maximum %
1.	Humanities & Social Sciences	17.2	10.9	32.0
2.	Mathematics	12.4	10.7	15.1
3.	Basic Sciences	17.5	6.2	32.9
	a. Chemistry	8.2	3.1	14.3
	b. Physics	6.7	3.1	8.5
	c. Biology	2.6	0.0	10.1
4.	Engineering Science	26.4	14.5	44.8
5.	Environmental Engineering	14.6	8.9	25.7
6.	Electives	10.5	4.1	22.7

A list of the environmental engineering option courses and basic and engineering subject matter of Table 23 science support courses is proposed as in Table 24. This is based on the philosophy of a broad education with the course content "tailored" to meet local or regional employment demands. Also, to meet employment needs schools will find it more advantageous to concentrate their electives in a particular area of environmental engineering, such as, water supply, atmospheric control, solid waste management, energy conversions, and others. Additional help in describing coursework is available from the work of Cook.[8]

TABLE 24. Proposed Minimum Coursework in Undergraduate Environmental Engineering

OPTION COURSES	BASIC AND ENGINEERING SCIENCES SUPPORT
Required:	
Basic Measurements	Math through Differential Equations (to include Probability & Statistics)
Water Supply and Hydrology	Physics through Fluid Mechanics
Water/Wastewater Treatment Systems	Chemistry through Process Control
Atmospheric Pollution Control	Biology through Microbiology
Solid and Hazardous Wastes	Engineering Economy
Environmental Impacts (noise, heated discharge, radiation, management, regulations, etc.)	Computer Programming
Capstone Design/Synthesis	
Electives:	
Specific for employment	
Usually an expansion of the required courses	

The development of the proposed coursework of Table 24 assumes that the coursework in Mathematics, Physics, Chemistry, Biology, and Engineering Science is sufficient to understand the required subject matter of option courses listed in Table 24.

3. Employment

In 1979, approximately 52,600 engineers were graduated with an undergraduate degree. Of these, only 284 were environmental engineers.(9) Frequently jobs requiring the education of an engineer(9) are filled by someone from another discipline (civil, chemical, etc.). The scarcity of engineers, entry salary level, and a variety of other reasons are given to explain why even a non-engineer was hired.

If the talents of environmental engineers are in demand, employers should make their demands known.

Frequently, an employer only knows the general type of person needed. Check the interview list at a University for the listing of undergraduate environmental engineering as a needed discipline. Albeit the list will be short. University recruiting people should be made aware of the educational background (coursework) and type of work the undergraduate can do. Also, meetings with visiting interviewers can be helpful. The interviewer and the employer may not be aware of their exact needs. Thus, environmental engineers may be overlooked.

One of the major problems is the education of the general public, high school counselors, and employers. Aulenbach(10) and others have recognized the need for educating not only the student but also the employer. There are now undergraduate environmental engineers who are capable of evaluating, designing, operating, and managing pollution problems at all levels, from collecting waste to generating energy.

4. Student Chapter

Students need identity, especially at the undergraduate level. There now exists, for many engineering disciplines, identity with practicing engineers through student clubs and chapters of a national level organization. This activity provides opportunities for the undergraduates to learn of job opportunities, exchange ideas, and most of all to identify and be part of a profession. Undergraduate environmental engineers frequently join chapters of other engineering disciplines, such as, civil engineering and chemical engineering. Possibly, this practice should be continued because technical literature and job opportunities can be found with these contacts through the student chapter functions. However, if the civil and other engineering clubs and chapters are not available, then some environmental engineering identity should be made available.

A problem which arises in organizing a student chapter is that of affiliation. To encompass all environmental engineering specialties, affiliation with WPCF, APCA, etc., is not adequate. Further, affiliating with any engineering society or using the name engineering in the club title tends to exclude any otherwise interested non-engineers. To be most effective, a club should be attractive to all individuals with a concern for the environment. It may then further show attendees how the problems may be resolved with an engineering solution.

In addition, it may be advantageous to consider an honorary Environmental Engineering Association. A social/technical chapter and an honorary association should be considered for development. If environmental engineering is to continue, identity for the student would be beneficial in those early (baccalaureate level) days of education.

B. OPTIONS IN THE UNDERGRADUATE PROGRAM

The evaluation of existing undergraduate programs indicates a fairly wide diversity in the emphasis in the individual programs. The emphasis may be divided into the major program and the courses which may be taken as a minor. There is considerable controversy over whether or not there should be such diversification at the undergraduate level. It is generally considered that the undergraduate program should be a basic program in environmental engineering concepts. However, in many instances there is still concern in water resources. Therefore, in such programs students receive an undergraduate background in only the water resources aspect and frequently do not receive much, if any, education in the other fields. This always presents a problem in terms of how much background should be provided in the various fields of environmental engineering at the undergraduate level.

1. Majors

It is generally considered that the 3 most basic majors in an environmental engineering program are water, air, and solid wastes. These concepts were established at the Third

Conference of Environmental Engineering Education.[11] At that conference there was consideration of adding the radiological health program to become a fourth category; however, this was considered merely a special industrial type waste and was not included as a separate major.

It is recommended that some aspect of all 3 of these fields be covered in all environmental engineering undergraduate programs. There should difinitely be consideration of the interrelationships of these 3 fields. In general, at the undergraduate level there is insufficient time in the program to have a separate course in all 3 fields. Thus, several different topics must be combined in certain courses. This always brings up the problem as to how much of each topic will be covered. Unfortunately, this is frequently the option of the individual teacher and in some cases, a desirable portion of a specific program at a certain school. It is generally recommended that students be made aware of all three fields at the undergraduate level and their interrelationships. There should also be an option to take additional courses in any of these 3 fields up to the limit of the available electives at the undergraduate level. The in-depth study of any one of these fields should be left to the graduate program.

2. Minors

Minors here are considered a significant emphasis in some field other than environmental engineering. Minors that could be considered would include chemistry, biology, chemical engineering, civil engineering, geology, oceanography, and management. It is possible to conceive of other potential minor topics. The chemistry and biology minors would be particularly interesting to a student interested in sciences. The chemical engineering minor would be of interest to students considering process design. Many of the basic aspects of chemical engineering are very important in the design of water and wastewater treatment processing. The civil engineering option would be of interest to those more concerned with the design and construction of facilities. This has been the traditional environmental engineering background. This becomes one of the more commonly chosen options. A geology minor would be of interest to individuals concerned with ground water and possibly land application of waste waters. Oceanography would be of interest to many individuals particularly where a school is located with a facility close to the ocean. Management is always an important concern since many students end up eventually in a management position.

Again the biggest concern here is the availability of time to take any of these minor courses. Obviously, no student could take all of these, but it is frequently possible to take 1 or 2 additional courses in one of these minors. Taking a minor course can have benefit at the undergraduate level by giving the individual a broader knowledge and greater opportunity to take a job in a broad field. On the other hand the minor courses could be of benefit in the graduate program, enabling the student to apply information from the minor program, particularly in his research, and of course his studies. Whereas, minors are useful, there is seldom sufficient time in both programs to take advantage of them.

C. GRADUATE TRAINING OF THE BACCALAUREATE ENVIRONMENTAL ENGINEER

1. Advanced Environmental Engineering Courses

The recommended courses for a graduate program in Environmental Engineering vary widely depending upon the baccalaureate education of the student, the specific interests of the student and in part the institute the student attends.

Baccalaureate scientists entering this discipline have a background that is generally deficient in engineering and applied science courses. Such students must take a variety of make-up courses for nongraduate credit and may be at a significant disadvantage in the graduate level engineering courses when they compete with students having an engineering background. Sometimes this may lead such students to take a range of introductory courses and pursue a general program having breadth at the expense of depth.

By comparison baccalaureate engineers perhaps with the exception of chemical engineers frequently enter graduate environmental engineering programs with deficiencies in the sciences. Civil engineers for example are generally weak in chemistry. These weaknesses and deficiencies may be corrected in the junior/senior years by engineering students who exercise environmental options. Otherwise students may find it necessary to strengthen their science background for their chosen environmental engineering graduate program.

The undergraduate environmental engineer by comparison has completed a program of study at the undergraduate level that provides a sound background in both the sciences and engineering science. In addition most undergraduate environmental engineering programs introduce the basics of environmental engineering and provide a broad general education. As a result when a baccalaureate environmental engineer enters a graduate program in this field he/she does not need to make up basic science or engineering science deficiencies. They therefore may exercise a greater degree of choice in selecting graduate courses. They are able to select courses for their program which give them a greater depth of understanding in a particular area of environmental engineering.

At the graduate level baccalaureate environmental engineers should be encouraged to take a program of courses designed to improve their depth of understanding in a particular area of the field. For example in the water quality area students should be encouraged to take courses that provide them with more analytical ability. Advanced courses in the theory and design of unit processes/operations, advanced aquatic chemistry, modeling courses, systems analysis, etc., would meet this objective and complement their undergraduate education to best advantage.

Since many undergraduate environmental engineering programs are quite rigid in their content and a student is required to complete a broad range of pertinent background and introductory courses it is clear that these students may be allowed to pursue a less structured Masters degree compared to students having different backgrounds. These students should be freer to choose courses for their program that reflect their interests. In this regard it does not seem appropriate to attempt to specify courses that should be taken at the graduate level. Only that introductory and general courses should be discouraged in favour of more advanced courses.

2. Non-environmental courses

An environmental engineer has many roles to fill. Not all of these are strictly engineering in concept. Public relations and social and political attitudes frequently follow a different path from a strictly technical decision. This frequently occurs in environmental impact statements and environmental impact hearings. In addition, legal concepts and interpretations may not always follow the most technical concepts. The graduate programs usually afford many opportunities for an undergraduate environmental engineer to gain knowledge in these "non-environmental" concepts.

In reality, these so-called non-environmental concepts are very important in the overall environmental concern. The finest technical solution to a problem is worthless if it cannot be explained or sold to the public and consummated. Thus, such courses are very essential to the program even though they are not considered strictly engineering courses. This presents a distinct advantage of an undergraduate environmental engineering program in order to allow such diversion at the graduate level.

3. Thesis or Project

It was concluded at previous conferences on environmental engineering education that a thesis or project is very desirable for the graduate student. This allows the student to perform independent study, to prepare a report, and to present that report. In almost any job the graduate accepts, the individual will be required to perform some of these functions.

In a few instances a thesis or project may be waived, particularly for a student who has had previous work experience which allowed the individual to conduct studies and write reports. These reports should be submitted for evaluation in lieu of the thesis. The thesis or project should be considered as an important part of the education of environmental engineers.

D. GRADUATE TRAINING OF THE BACCALAUREATE SCIENTIST

Previous environmental engineering education conferences have recognized the fact that environmental engineering entails a considerable amount of science education. Students in general are required to take courses in Biology, Chemistry, and possibly Physics or Physical Chemistry. It is clearly recognized that the problems involved in environmental engineering are closely related to these sciences. Thus, environmental engineering graduate programs have frequently attracted non-environmental engineering students whose backgrounds have been in Chemistry or Biology. This has created some problems in terms of the course work at the graduate level. Two options seem to be open: one to offer a Master of Science degree and the other a Master of Engineering degree. Confusion occasionally occurs when one receives a Master of Science in Environmental Engineering. Further discussion of the distinction between the environmental engineer and the environmental scientist is continued in Section F.

1. Master of Science Program

There are many opportunities for an individual who would like to receive an M.S. degree in the field of environmental engineering. The individual would retain his basic concepts of the sciences, but would be able to apply these to an engineering concern. Potentially the individual would become an applied scientist, which is very closely related to an engineer. The degree recipient could certainly converse with and relate to environmental engineers. One of the concerns with this route is the possible avoidance on the part of the student of taking the undergraduate engineering courses. This would make it easier for the individual to complete the graduate program without making up numerous undergraduate programs for no credit. Experience has shown that this individual could take nearly all of the graduate engineering courses and would, therefore, have as much knowledge in environmental engineering as an undergraduate engineer. Thus, it is not considered unreasonable to offer the individual the degree which has the words environmental engineering on it. However, it must be realized that this person is not an engineer.

One of the biggest problems involved in the non-engineering undergraduate student is the lack of mathematics courses and engineering sciences courses related to the graduate program. Experience has shown that these students frequently have difficulty with the math involved in the graduate level environmental engineering courses. Thus, it is recommended that the required math courses be made up by the science undergraduate student entering into a graduate program in environmental engineering.

There may be instances in which engineering concepts will be mentioned in a graduate environmental engineering course, with the assumption that the student already has had these concepts. In these instances it may be necessary to make available to the student additional references or reading to make up the necessary engineering background. If a student has a good education, self-learning should not be too difficult.

2. Master of Engineering Program

Many science baccalaureate degree recipients desire to go into an environmental engineering program and receive a degree of engineering. The recipient would then receive a Master of Engineering degree in Environmental Engineering, which in general receives ECPD accreditation. To some this accreditation is considered essential, particularly if the individual intends to apply for a P.E. license sometime in the future. Such a decision requires the student to make up the required undergraduate engineering courses, including the required math courses. This brings up two problems, one being the receiving of credit for undergraduate courses and the other being related to the balance of the number of undergraduate versus graduate credits.

a. Credit

In general it must be considered that the undergraduate engineering courses would have to be made up with no credit toward the master's program. This obviously would involve most likely one additional semester of work. This would delay the receipt of the degree and should be explained to the student at the initiation of such program. In some instances the receipt of financial support does not include payment for such undergraduate courses. This could potentially put a greater strain on the student and discourage the student from following this course of action. On the other hand it may be worthwhile to the student to make up all these courses in order to obtain a potentially better job and a P.E. license.

b. Balance of advanced courses

Most graduate programs specify a balance of graduate or senior level versus undergraduate courses. In general this is a one to one ratio or 50 per cent graduate courses and no more than 50 per cent undergraduate level courses. Inasmuch as most of the undergraduate engineering courses are not advanced courses, this would lower the ratio of advanced to undergraduate level courses. It is already assumed that the student would take more than the required (usually) 30 graduate credits for graduation, so the total number of courses is not a problem. However, if one takes less than senior level undergraduate courses, and averages these with the senior and graduate level courses, this would pull down the average to an insufficient number of advanced courses. Therefore, it is normally recommended that these undergraduate courses not be counted in the total course work for the Master of Engineering program, but that the courses should be recorded in the student's transcript. Credit should most likely be given for the courses, but they should not be considered in the balance between the graduate and undergraduate course work.

E. GRADUATE TRAINING OF THE BACCALAUREATE ENGINEER OTHER THAN ENVIRONMENTAL ENGINEER

Very frequently graduates in civil engineering and chemical engineering elect to take a master's program in environmental engineering. The traditional program was a civil-sanitary program in which there was no opportunity to receive an undergraduate degree in Environmental Engineering. This pattern is still followed at many schools which do not have an undergraduate environmental engineering program, thus, there is no option other than to follow a non-environmental engineering baccalaureate program with an environmental engineering graduate program. At schools which do have an environmental engineering undergraduate program there are still some advisors who recommend a civil or chemical engineering undergraduate program followed by a graduate environmental engineering program. Students entering the environmental engineering graduate program from other engineering disciplines may have to make up some course work at the graduate level.

1. Requirement to make up undergraduate science courses

As has been mentioned, previous environmental engineering education conferences have shown the need for science courses in the environmental engineering program. In general the civil engineering baccalaureate degree recipient has only one (freshman) chemistry course and no biology. Chemical engineering undergraduates coming into the environmental graduate program frequently have sufficient chemistry and in some cases the organic and physical chemistry requirements. The three concerns in terms of making up these undergraduate courses at the graduate level are a) the concern for credit, b) the balance of graduate and undergraduate courses, and c) additional time in the graduate program to receive a degree.

a. Credit

Receiving credit for undergraduate level courses in chemistry and biology has frequently taken two directions. One is merely to take the courses at the undergraduate level and not receive credit. On the other hand, many schools, in an effort to provide additional service to the student, have arranged to give chemistry and biology courses with senior or graduate level credit. In many instances, however, these are merely undergraduate chemistry or biology review courses and are not truly advanced level courses. Schools have been known to give courses with dual numbering: one for normal undergraduate students and another for graduate students so that they may receive graduate credit for the course. In most instances additional work is given to those taking the course for graduate credit; however, there are no statistics on the prevalence of this activity. Very frequently remedial courses such as chemistry for environmental engineers or biology for environmental engineers are given in the environmental engineering program in order to make up the deficiencies in chemistry and biology. Most frequently it is impossible to teach these courses at the graduate level, since the students do not have the background and the course becomes a rather elementary review of chemistry and/or biology. The one advantage of teaching these courses in the environmental engineering curriculum is that their relevancy to environmental engineering problems may be shown readily.

b. Balance of graduate courses

One of the reasons that courses such as chemistry for environmental engineers are given as a senior or graduate level course is to maintain the balance of advanced versus undergraduate level courses. Most schools have a one to one balance of graduate or advanced courses versus undergraduate courses, and by assigning an advanced level denotion to the course it will go on the student's record as a graduate or advanced level course. One of the problems with this is that if the student builds up his program with these make-up courses he will not have room in his program for a sufficient number of graduate level environmental engineering courses. In general, it is recommended that the student be required to take more than the normal 30 graduate level courses in environmental engineering if making up undergraduate courses is required.

c. Time

This taking of additional courses does add additional time to the student's master's program. It is likely that this may add an additional semester or possibly a summer to the graduate program. Usually master's candidates do not complete all their graduate work in the shortest possible period of time because they have not completed their thesis or project work. Therefore, in general, the small additional time in making up these chemistry and biology courses does not delay the time of receipt of the degree as opposed to not having spent the time making up these courses. Thus, in general, this is not an additional burden on the student.

F. DISTINCTION BETWEEN ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL SCIENCE DEGREE RECIPIENTS

As university programs in the environmental area have grown, the variety of degree programs and the number of non-engineers entering these programs have created occasional problems. Of concern here are these areas: (1) clarity of distinction between environmental science and environmental engineering baccalaureate degree programs, and (2) the distinction between science and engineering degrees on the graduate levels, and (3) other distinctions drawn between non-engineers and engineers on the graduate level.

The first item is seemingly simple to define by applying the test of accreditability by ECPD. However, as noted by Patterson and Male,[7] this distinction is often lost on high school students wishing to enter the environmental field. It is also apparent that high school counselors (and all too often university advisors outside engineering) do not understand the distinction either. Efforts should be made to clearly distinguish engineering from science programs in university bulletins and brochures, and engineers should find ways to educate those in a position to advise prospective students.

Items (2) and (3) are intertwined to some extent. Employers and other universities often find it confusing to find both engineers and non-engineers graduating from the same university, the same program, with essentially (if not identically) the same coursework in the graduate program, and either the same degree title or a very similar one. Item (2) deals with the need for honesty and clarity in degree titles. Examples exist today (1980) in which environmental degrees with the word "Engineer" in the title are awarded to students with non-engineering baccalaureate degrees. Some of these students have found it necessary to enter a bachelor's degree program in engineering (after already obtaining, supposedly, a master's degree in "engineering"). Acquiring the ECPD accredited undergraduate degree will clarify their status with respect to licensing exams, for example, which in many state agencies is a requirement for advancement beyond a certain plateau. This extreme step is not advisable for all people, but highlights the need for judicious use of the word engineering in degree titles. Degree titles should be clear and easily interpreted.

Even if degree designations clearly define an engineering degree as opposed to a science degree, confusion can continue to exist. This is especially true when a review of transcripts reveals that engineers and non-engineers alike take very similar or identical coursework. Distinctions in course programs usually become greater for those progressing on to the Ph.D. as students emphasize more specialized work. However, on the master's level, programs are often very similar (except perhaps in the largest programs). Deans and other academically interested people ask the cogent question, "If this is an engineering graduate course, how can non-engineers take it?" While good arguments can be made for the value of a basic science background in many environmental courses, it is true that truly environmental engineering courses assume some previous level of engineering exposure prior to the course. Unfortunately, there is apparently a wide diversity of opinion as to how extensive that background should be. Some programs require, simply, an ECPD - accredited baccalaureate degree. On the other end of the spectrum are those programs which allow non-engineers to obtain the degree designated "Engineering" by completing a rather small number of math and engineering courses (e.g., fluid mechanics). This further confuses those viewing the program and its graduates. Discussion needs to occur enabling thoughts on this topic to be shared and perhaps refine feelings of desirable prerequisite (or makeup) work for non-engineers. It is expected suggested criteria will be different for those non-engineers in science programs and those who want to attain an engineering degree.

G. SUMMARY AND RECOMMENDATIONS

As the demand for a cleaner environment and alternative energy sources increase, the discipline of environmental engineering could provide talent to help identify and solve many of these social needs. For the last decade, undergraduates were exposed to the philosophies of environmental engineering together with basic science, engineering sciences, and environmental engineering education. This exposure should be continued. It is believed that undergraduate environmental engineering education can be enhanced to better serve society. However, coursework must be structured to recognize a broad base of environmental engineering activities and adapted to local or regional needs. In addition, employers must be more aware of their needs, professors must sell their product, and students must have identity.

The following specific recommendations are made:

1. It is desirable to maintain a diversity of programs in environmental engineering with options in a general program or emphasis in water, air or solid wastes.

2. A baccalaureate program in environmental engineering provides an excellent foundation for advanced degrees in environmental engineering.

3. An individual holding a baccalaureate degree in an engineering department other than environmental engineering will be expected to make up certain non-engineering courses appropriate to environmental engineering.

4. An individual holding a non-engineering baccalaureate degree and desiring an advanced engineering degree will have to make up certain basic engineering courses, resulting in a longer time for degree achievement.

5. Engineering and science programs and degrees should be clearly distinguished in university bulletins and brochures, and engineers should seek ways to educate those advising students.

6. Graduate degree titles should be clear, easily interpreted, and draw a clear distinction between science and engineering degrees.

7. Further effort should be made to define an acceptable set of background courses to be taken by non-engineers, with more required of those entering the engineering program.

8. Student environmental engineering chapters or clubs should be encouraged. Faculty members should be interested enough to serve as advisors.

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11. Proceedings of the 3rd National Environmental Engineering Education Conference, August 13-15, 1973, Drexel University, AAEE and AEEP.

DISCUSSION GROUP REPORT

RELATIONSHIP OF BACCALAUREATE TO GRADUATE ENVIRONMENTAL ENGINEERING EDUCATION

1. There is a need to provide the manpower necessary to address the environmental engineering questions of the future. Such a need can be met partially by a baccalaureate degree in environmental engineering. This degree should provide the mix of science and engineering not available generally in other established undergraduate engineering disciplines. Therefore, where appropriate, undergraduate environmental engineering degree programs should be encouraged to meet these needs. Such baccalaureate degree programs are not intended to replace existing graduate programs, but instead will permit the upgrading of these graduate programs. It should be recognized that in institutions pursuing such degree programs careful analysis may have to be made of the impact upon existing graduate programs.

2. It is recommended that the 1975 and 1980 curricula of the undergraduate environmental engineering degree programs be appended to the report of this conference proceedings.

3. It is recommended that AEEP/AAEE be requested to distribute public relations materials describing the work of environmental engineers, their educational background and entry level salaries. In addition, a survey of employment possibilities should be conducted including the nontraditional employers of environmental engineers.

4. Items 1, 2, 3 should replace original Recommendations 1 and 2 on page 164 of the Position Paper.

5. It is recommended that AEEP conduct an annual survey of undergraduate environmental engineering enrollment and placement in addition to the existing survey of graduate enrollment.

6. It is recommended that AEEP consider the formation of an association of environmental engineering students.

7. It is recommended that Recommendation No. 6 replace Recommendation No. 8 on page 165 of the Position Paper.

8. Graduate degree titles should be clear, easily interpreted, and draw a clear distinction between science and engineering degrees. An individual receiving a degree with the word engineering in the title shall meet the minimum ECPD/ABET baccalaureate degree requirements. (Passed 8y, 4n, 1a)

9. We recommend Herb Bevis conduct the survey outlined in Recommendation 5.

10. We recommend the Publications Committee of AEEP prepare a new promotional brochure as outlined in Recommendation 3.

11. An individual holding a baccalaureate engineering degree other than environmental engineering will be expected to make up certain courses appropriate to environmental engineering.

12. Engineering and science programs and degrees should be clearly distinguised in university bulletins and brochures. (Passed 9y, 4n)

13. Delete Item 7, page 165 of Position Paper.

14. Change Conference Paper page 150 line 24 to read . . . and managing a variety of pollution problems, from collecting wastes . . .

PLENARY SESSION ACTIONS

RELATIONSHIP OF BACCALAUREATE TO GRADUATE ENVIRONMENTAL ENGINEERING EDUCATION

The discussion group report was presented to the Plenary Session by Don Aulenbach and Jim Heaney.

Item 1 — Jack Nesbitt moved acceptance of Item 1, Dave Peterson seconded the motion.

Charlie O'Melia moved to change will to may in sentence number 4. Stan Klemetson seconded the motion which passed without opposition.

There was discussion on the amended motion. Shuval spoke against the motion. He felt that the baccalaureate program was a disservice to both the student and the professor by narrowing job options at an early stage in the students' education. He was not in favor of endorsing the concept of a B.S. program in environmental engineering.

Rolf Kayser stated that he was in favor of B.S. concept.

Herb Bevis spoke in favor of the B.S. concept and pointed out that they (University of Florida) have an undergraduate program specifically in environmental engineering.

Another amendment was proposed. Klemetson moved and Okun seconded to delete the second sentence. The amendment passed 41 to 8.

The amended motion was brought to a vote and failed, 20 to 26. (Note item was brought up again later.)

Item 2 — Steve Shelton moved to delete Item 2 (effectively bringing the item to a vote such that passage of the motion defeated the item). Alan Rubin seconded the motion.

The motion passed unanimously (thus defeating Item 2).

Item 3 It was moved by Dave Peterson that Item 10 be incorporated with Item 3 for consideration. Gus Rossano seconded this motion. It was implied from that the intent was then to move for acceptance of the joint motion.

Wendle Hovey moved to amend the motion such that information on entry salary levels be deleted from the item. Seconded by Hal Cooper, the amendment passed by voice vote.

The amended motion passed without opposition.

Item 4 Withdrawn by the discussion group leaders in view of previous action.

Item 5 Don Aulenbach moved for acceptance of the item. Alan Rubin seconded the motion.

In discussion, Chuck Haas suggested that this item might simply be referred to the AEEP Board of Directors. This was accepted as a substitute motion and passed by voice vote without opposition.

Item 6 Alan Rubin moved, Hal Cooper seconded, that this item also be referred to the AEEP Board of Directors for action. The motion passed by voice vote without opposition.

Item 7 This item was deemed an editorial matter and not brought forward for a vote.

Item 8 Jack Nesbitt moved acceptance of the item. His motion was seconded by Stan Klemetson.

Chuck Haas moved that the second sentence be deleted from the item. Steve Shelton seconded the motion. The amendment failed 18 to 22.

A new amendment was proposed by Alan Molof and seconded by Hal Cooper, that ABET requirements will be interpreted by senior environmental engineering faculty holding a B.S. degree in engineering. The motion was defeated by a large margin.

Stan Klemetson then proposed that ECPD/ABET engineering science, design and requirements be inserted in the item. Cliff Randall seconded the amendment. The amendment was defeated 10 to 19.

Another amendment was proposed by Dave Peterson to add the words, "in the environmental discipline," between the words, "titles," and, "should," in the first sentence. This amendment passed by a substantial margin.

The amended motion passed by a vote of 25 to 18.

Item 9 This item was direct for consideration by the Board of Directors.

Item 10 Incorporated previously into Item 3.

Item 11 Don Aulenbach moved for acceptance of the item as written. Hal Cooper seconded the motion. The motion was defeated by a significant margin.

Item 12 Don Aulenbach moved for acceptance of the item as written. Alan Molov seconded the motion. The motion passed by a vote of 20 to 11.

Item 13 Deletion of Item 7, page 165 of the Position Paper did not require a vote since the working group prepared the paper, they had license to modify the paper.

Item 14 This item was declared an editorial matter.

Shuval proposed two new motions in light of the defeat of Item 1. The first of these read.

> "Change the name of Issue 2 to Baccalaureate Programs in Environmental Engineering." Phil Singer seconded the motion. The motion was defeated by a significant majority.

Hillel Shuval's second motion was to insert the following:

"There were considerable differences of opinion as to the need and desirability of baccalaureate programs in environmental engineering and its contribution to graduate study in the field. However, in recognition of the existance of a number of such programs it was decided that the conference deal with certain aspects of these programs." The motion was seconded by Dave Peterson - this motion was also defeated.

Item 1 was again resurrected in a motion by Bruce Hanes and a second by Wendel Hovey to read as follows:

"There is a need to provide the manpower necessary to address the environmental engineering questions of the future. Such a need can be met partially by a baccalaureate degree in environmental engineering. Such baccalaureate degree programs are not intended to replace existing graduate programs."

An amendment to this motion was proposed by Chanel Ishizaki and seconded by Steve Shelton to add the original third sentence to the statement. The amendment was defeated.

Vote on the motion: The motion was passed by a significant majority and Item 1 was restored to Issue 2 as given above.

ADDITIONAL PLENARY SESSION ACTIONS

RELATIONSHIP OF BACCALAUREATE TO GRADUATE ENVIRONMENTAL ENGINEERING EDUCATION

Having completed review and voting on each of the issues, two additional motions were submitted from the floor by Maurice Shapiro.

1. A major concern voiced at the Fourth Conference on Environmental Engineering Education is the lack of sufficient opportunities for professional faculty development. It is therefore moved that AEEP/AAEC develop a seminar/workshop on teaching evaluation and improvements to be held as soon as possible but no later than 1983. While the motion was seconded by Steve Shelton it was not brought to a vote since there already is a Committee structure for this activity and the Board of Directors have direct power to select such a workshop topic and structure a committee to develop and represent the workshop. Therefore, the motion was considered instead to be a recommendation to the Board of Directors.

2. "In the spirit of reaching for excellence in the overall protection of health and the environment it is now moved that all smoking at Conference meetings and sessions be henceforth prohibited. Numerous seconds were voiced and the motion passed by voice vote.

After closing remarks by the Conference Chairman, the session was adjourned at 12:45 p.m.

REGISTRANTS
FOURTH CONFERENCE ON ENVIRONMENTAL ENGINEERING EDUCATION

Dr. Barry J. Adams
Department of Civil Engineering
University of Toronto
Toronto, Ontario M5S 1A4
CANADA

Dr. Avner Adin
4/11 Ezel Street
Jerusalem
ISRAEL

Dr. John F. Andrews
University of Houston
Houston, Texas 77090

Dr. Donald B. Aulenbach
Division of Environmental Engineering
Rensselaer Polytechnic Institute
Troy, New York 12181

Professor Peter Balmer
Department of Sanitary Engineering
Chalmers University of Technology
S 41296 Gothenburg
SWEDEN

Dr. Edwin L. Barnhart
Department of Civil Engineering
Southern Methodist University
Dallas, Texas

Dr. Georges Belfort
Rensselaer Polytechnic Institute
Troy, New York 12181

Professor W.C. and Helene Belschner
4860 Rosedale Avenue
Montreal, Quebec H4V 2H2
CANADA

Professor Jaime Benitez
Chemical Engineering Department
R.U.M.
Mayaguez, Puerto Rico 00708

Dr. Herbert A. Bevis
Department of Environmental Engineering
University of Florida
Gainesville, Florida 32611

Dr. S.K. Bhagat
Sloan 141
Washington State University
Pullman, Washington 99164

Professor W. Bulani
Fac. of Eng. Sc.
U.W.O.
London, Ontario N6A 5B9
CANADA

Dr. Paul Busch
Malcolm Pirnie, Inc.
2 Corporate Park Drive
White Plains, New York

Professor Philip Byer
Department of Civil Engineering
University of Toronto
Toronto, Ontario M5S 1A4
CANADA

Mr. William J. Carroll
250 North Madison
Pasadena, California 91101

Dr. Manuel Carrondo
Universidad Novade Lisboa
Av. Republica
65, 7o 7000 Lisboa
PORTUGAL

Dr. Russell F. Christman
Department of Environmental Sciences
and Engineering, SPH
University of North Carolina
Chapel Hill, North Carolina 27514

Dr. Robert C. Cluster
Post Office Box 1148
Fort Collins, Colorado 80522

Dr. John J. Cochrane
236 Huntington Avenue
Boston, Massachusetts 02115

Mr. Douglas W. Cooper
665 Huntington Avenue
Boston, Massachusetts 02115

Dr. Hal B.H. Cooper, Jr.
University of Texas at Austin
Department of Civil Engineering
Austin, Texas 78712

Dr. Rolf A. Deininger
School of Public Health
University of Michigan
Ann Arbor, Michigan

Professor Luis A. del Valle
Civil Engineering Department
R.U.M.
Mayaguez, Puerto Rico 00708

Dr. Francis A. DiGiano
Department of Civil Engineering
University of Massachusetts
Amherst, Massachusetts 01003

Dr. Richard I. Dick
118 Hollister Hall
Cornell University
Ithaca, New York 14853

Dr. Benjamin C. Dysart III
401 Rhodes Research Center
Clemson University
Clemson, South Carolina 29631

Gerard C. Etienne
525 - 23rd Street, N.W.
Washington, D.C. 20037

Dr. Earnest Gloyna
ECV 10.310
University of Texas
Austin, Texas 78712

Mr. Ronnie Gehr
Department of Civil Engineering and
Applied Mechanics
McGill University
817 Sherbrooke Street, W.
Montreal, Quebec H3A 2K6
CANADA

Dr. Charles N. Haas
Environmental Engineering
Rensselaer Polytechnic Institute
Troy, New York 12181

Dr. N. Bruce Hanes
Department of Civil Engineering
Tufts University
Medford, Massachusetts 02155

Dr. James P. Heaney
Department of Environmental
Engineering Sciences
University of Florida
Gainesville, Florida 32611

Professor G.W. Heinke
Department of Civil Engineering
University of Toronto
Toronto, Ontario M5S 1A4
CANADA

Dr. David W. Hendricks
Engin. Res. Center
Colorado State University
Fort Collins, Colorado 80523

Professor Glynn Henry
Department of Civil Engineering
University of Toronto
Toronto, Ontario M5S 1A4
CANADA

Mr. Wendell H. Hovey
Post Office Box 181
N. Windham, Connecticut 06256

Dr. Ju-Chang (Howard) Huang
Professor of Civil Engineering
University of Missouri - Rolla
Rolla, Missouri 65401

Dr. Chenel Ishizaki
I.V.I.C. Apartado 1827
Caracas 1010-A
VENEZUELA

Dr. David Jenkins
University of California - Berkeley
11 Yale Circle
Kensington, California 94708

J. Peter Jones
Department of Chemical Engineering
University of Sherbrooke
Sherbrooke, Quebec
CANADA

Dr. Michael Kavanaugh
344 Lewis Street
Oakland, California 94607

Professor D. Rolf Kayser
Technische Universitat Braunschweig
Institute fur Stadtbauwesen
Abt. Siedlungswasser wirtschaft
Postfach 33 29, D-3300 Braunschweig
FEDERAL REPUBLIC OF GERMANY

Dr. T.M. Keinath
Environmental Systems Engineering
401 Rhodes
Clemson University
Clemson, South Carolina 29631

Dr. Bram Klapwijk
Agr. University
Department of Water Pollution Control
De Dreyn 12
Wageningen
HOLLAND

Dr. Stanley L. Klemetson
Engineering Research Center
Colorado State University
Fort Collins, Colorado 80525

Dr. Michael D. LaGrega
Bucknell University
Lewisburg, Pennsylvania 17837

Professor J.P. Lumbers
Department of Civil Engineering
Imperial College
London SW7 2AZ
ENGLAND

Dr. Richard G. Luthy
Department of Civil Engineering
Carnegie-Mellon University
5000 Forbes Avenue
Pittsburgh, Pennsylvania 15213

Dr. Joseph F. Malina, Jr.
Civil Engineering Department
The University of Texas
Austin, Texas 78712

Professor Saburo Matsui
Department of Construction and
Environmental Engineering
Kanazawa University
2-40-20 Kodatsuno
Kanazawa, 920
JAPAN

Allen J. Medine
Station Road
Hampton, Connecticut 06247

Dr. Perry L. McCarty
Civil Engineering Department
Stanford University
Stanford, California 94305

Dr. Roger A. Minear
Department of Civil Engineering
University of Tennessee
Knoxville, Tennessee 37916

Dr. Alan H. Molof
Polytechnic Institute of New York
333 Jay Street
Brooklyn, New York 11201

Mr. Joe G. Moore, Jr.
1414 West Shore
Richardson, Texas 75080

Dr. James J. Morgan
Keck Lab.
California Institute of Technology
Pasadena, California 91125

Dr. John B. Nesbitt
116 Sackett Building
University Park, Pennsylvania 16802

Dr. R.D. Neufeld
Department of Civil Engineering
University of Pittsburgh
Pittsburgh, Pennsylvania 15261

Dr. Daniel A. Okun
ESE - SPH 201H
University of North Carolina
Chapel Hill, North Carolina 27514

Dr. Charles R. O'Melia
Department of Environmental
Sciences and Engineering
University of North Carolina
Chapel Hill, North Carolina 27514

Dr. Philip S. Pagoria
Department of Civil Engineering
Old Dominion University
Norfolk, Virginia 23508

Dr. Frank L. Parker
Post Office Box 1596
Station B
Vanderbilt University
Nashville, Tennessee 57235

Dr. James W. Patterson
Chairman, Pritzker Department
of Environmental Engineering
Illinois Institute of Technology
3200 South State Street
Chicago, Illinois 60616

Dr. Roger Perry
Department of Civil Engineering
Imperial College
London SW7 2AZ
ENGLAND

David Peterson
Department of Paper Science
and Engineering
Western Michigan University
Kalamazoo, Michigan 49008

Dr. Frederick G. Pohland
School of Civil Engineering
Georgia Tech
Atlanta, Georgia 30332

Dr. P.W. Purdom, Director
Environmental Studies Institute
Drexel Univeristy
Philadelphia, Pennsylvania 19104

Mr. Thomas P. Quirk
Gateway 80 Office Park
Wayne, New Jersey 07470

Dr. Clifford W. Randall
Department of Civil Engineering
VPI & SU
Blacksburg, Virginia 24061

Dr. Chet A. Rock
457 Aubert Hall
Department of Civil Engineering
University of Maine
Orono, Maine 04469

Dr. Gerard A. Rohlich
2101 Pecos Street
Austin, Texas 78703

Dr. August T. Rossano
9427 NE 20th
Bellevue, Washington

Dr. Alan J. Rubin
OSU Water Resources Center
1791 Neil Avenue
Columbus, Ohio 43210

Professor Stephen J. Sebesta
Department of Civil Engineering
Fenn College of Engineering
Cleveland State University
1983 East 24th Street
Cleveland, Ohio 44155

Dr. Maurice A. Shapiro
Room A726 - Crabtree Hall
GSPH - University of Pittsburgh
Pittsburgh, Pennsylvania

Jan Scherfig
School of Engineering
University of California
Irvine, California

Professor Hillel Shuval
Hebrew University of Jerusalem
Jerusalem
ISRAEL

Dr. Philip C. Singer
Dept. Env. Sci. Eng.
201H
Univeristy of North Carolina
Chapel Hill, North Carolina 27514

Professor Terje Simensen
University of Trondheim
7034 Trondheim
NORWAY

Dr. Werner Stumm
EAWAG
CH-8600 Dubendorf
SWITZERLAND

Norihito Tambo
Department of Sanitary Engineering
Hokkaido University
Sapporo 060
JAPAN

Ning-Hsi Tang
Civil Engineering Department
University of Puerto Rico
Mayaguez, Puerto Rico 00708

Dr. Robert V. Thomann
Environmental Eng. & Sc.
Manhattan College
Bronx, New York 10471

William P. Tully
College of Environmental Science
and Forestry
Syracuse, New York

Dr. P.A. Vesilind
Department of Civil Engineering
Duke University
Durham, North Carolina 27706

Dr. Alberto M. Wachs
Technion
Technion City, Haifa 32000
ISRAEL

Dr. Marty Wanielista
221 West Trotters Drive
Maitland, Florida 32751

Roy F. Weston
Roy F. Weston, Inc.
Weston Way
West Chester, Pennsylvania 19380

Frederick White
1103 Washington Avenue
Allentown, Pennsylvania 18103

Donald B. Wilson
Box 3805
Las Cruces, New Mexico 88003