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ABSTRACT

This report is based on the 1966 and 1969 registers of graduate programs in the field of sanitary engineering. Data for both registers were collected by questionnaires. The first in 1965 included 56 colleges and the second in 1969 included 45 colleges offering graduate programs. The following chapters are included: Objective of the Register; Program Titles and Objectives; Faculty, Admission Requirements; Degree Titles, Typical M.S. Programs, Degrees Awarded and Present Student Enrollment; Initial Employment of 1966-67 and 1967-68 Degree Recipients; Financial Support; Summary and Conclusions. The three principal program titles used are sanitary engineering, water resources engineering, and environmental engineering. The preponderance of programs are in water science and engineering. Programs are generally depicted as interdisciplinary in character. The report does not evaluate the quality of the programs, but recognizes that "quality is most dependent on the excellence of the individual faculty members." Numerous charts and graphs are employed in presenting data on the programs, degrees, faculty, and trends. (PR)

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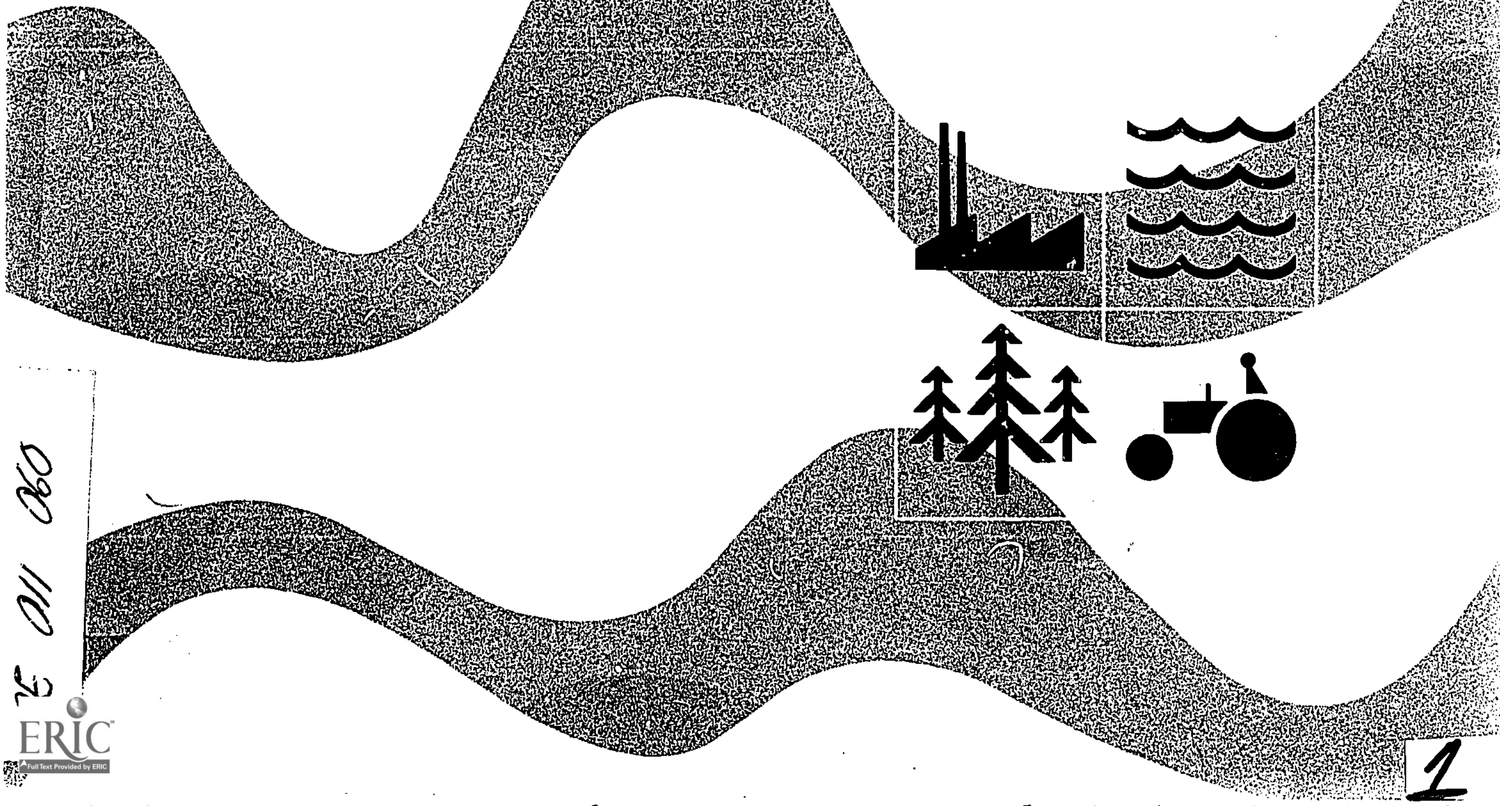
An Evaluation of Sanitary Engineering Education

PREPARED FROM THE REGISTERS OF
GRADUATE PROGRAMS IN THE FIELD OF
SANITARY ENGINEERING EDUCATION, 1966–1969

Sponsored by the
ENVIRONMENTAL ENGINEERING
INTERSOCIETY BOARD
and the
AMERICAN ASSOCIATION OF PROFESSORS
IN SANITARY ENGINEERING



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AN EVALUATION OF SANITARY ENGINEERING EDUCATION.

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INTRODUCTION

Perhaps the greatest underlying problem of sanitary engineering education is the diversity of interests and activities of its membership and the fact that these same interests are shared with a growing host of other professional and scientific disciplines. In 1943 the National Research Council Committee on Sanitary Engineering and Environment set forth a definition of the term "sanitary engineering." This was revised in 1954 and considered further by the same committee under the chairmanship of Professor Abel Wolman in March 1957, with the financial assistance of the Public Health Service. It was agreed that the practice of sanitary engineering included water supply and treatment; sewerage and sewage treatment; surface and groundwater pollution control; general environmental sanitation, including milk and food inspection; institutional, rural, and recreational sanitation; the control of atmospheric pollution; industrial hygiene; and radiological health; and "other fields that have as their major objectives the control of environmental factors affecting health." In the 1957 Conference Report five fields of sanitary engineering were identified: public health, waterworks and waste disposal, industrial hygiene, radiological health, and air pollution control. All of these fields of professional activity were at that time largely the responsibilities of health agencies at all levels and for the most part fell within bureaus or divisions headed by sanitary engineers.

In 1960 the American Sanitary Engineering Intersociety Board sponsored a conference on the Graduate Education of Sanitary Engineers which was held at Harvard University in June of that year. Here we began to see some of the first evidence of a schism in the profession and the emergence of such terms as "water resources engineering" and "air resources engineering" and the replacement of the traditional "public health engineering" designation with the more euphonious and timely "environmental health engineering." A title acceptable to all fields of sanitary engineering was considered desirable for the "promotion of the spirit of the profession and mutual esteem of the members thereof" and it was resolved that this question be referred to ASEIB for further study. In February of 1966, after nearly six years of consideration, ASEIB changed its name to Environmental Engineering Intersociety Board (EEIB).

Whereas the traditional concept of the sanitary engineer, as stated in the various National Research Council (NRC) Committee Reports, assigns him a broader role than water quality management, today the generic term <u>environmental engineering</u> has assumed the meaning of the historical designation sanitary engineering. The latter term has become the species designation for water quality management. It is not likely that a single individual can fulfill all the requirements of an environmental engineer and represent himself as such. This circumstance has been recognized by EEIB and the American Academy of Environmental Engineers. The new certificates issued to diplomates of the Academy will carry only one of four specialty designations:

Sanitary Engineering
Industrial Hygiene Engineering
Air Polution Control Engineering
Radiation and Hazard Control Engineering.

Nine years have passed since the June 1960 Study Conference on the Graduate Education of Sanitary Engineers. During that interval a number of significant changes have occurred that make it appropriate for the profession to reexamine its educational objectives and resources. The changing role of the sanitary engineer in the federal establishment was recognized when the functions of water pollution management were transferred from the Public Health Service to the Department of the Interior's Federal Water Pollution Control Administration (now the Federal Water Quality Administration). Perhaps more important, yet less tangible, has been the growing public concern for all aspects of environmental pollution and the increasing awareness among engineers, particularly those from civil engineering, of their rather special responsibilities for the environment. It was because of this concern and its meaning to our educational programs that the American Association of Professors in Sanitary Engineering (AAPSE) was organized in December of 1963. This awareness was also the reason for the preparation in 1966 of a new Register of Graduate Programs in the Field of Sanitary Engineering Education as a joint effort by AAPSE and EEIB to update the earlier Registers.

It is evident that environmental engineering is an interdisciplinary science based on the engineering and applied science fields for which man and his well-being are the principal focus. Although his is not the only profession concerned with the environment, the sanitary engineer, through his several decades of involvement in the management of water, air, food, and environmental pollutants, has certainly established his position in the environmental fields. It is noteworthy that the accomplishments and leadership of the sanitary engineer during this period led to the elimination or control of many communicable diseases rampant at the turn of the century. It is appropriate and timely that the sanitary engineer and his science colleagues examine this position vis-a-vis the needs of the nation, the probable nature of its future development, and the adequacy and requirements of the educational programs serving environmental engineering. This was the broad purpose of the 1967 Conference at Northwestern University. The results of the Conference were published under the title Report of the Second National Conference on Environmental and Sanitary Engineering Graduate Education. Copies are obtainable by writing to W. J. Kaufman, Division of Hydraulic and Sanitary Engineering, University of California, Berkeley, California 94720.

In 1960 and 1962 a Sanitary Engineering Education Directory was prepared by the Committee on Sanitary Engineering Education of ASEIB and edited by Professor Gilbert H. Dunstan. Included in the Directory were admission and degree requirements, a brief description of the faculties, and a roster of engineering schools offering graduate work in sanitary engineering. A total of 65 schools responded as offering graduate degrees in sanitary engineering and six additional schools of public health were included for a total of 71 institutions. No information was requested on financial support, on enrollment, or on the number of degrees granted. Since publication of the 1962 Directory, many changes have occurred in the profession, as noted earlier, particularly in the academic sector and in the financial support that it has received from federal sources. Early in 1966 the Board of Directors of the American Association of Professors in Sanitary Engineering (AAPSE) authorized an education study and evaluation under the direction of Professor R. O. Sylvester and with the assistance of Professors G. H. Dunstan, P. A. Krenkel, W. J. Kaufman, and R. C. Loehr. The Environmental Engineering Intersociety Board (formerly ASEIB) was asked to participate in the development of the Register of Graduate Programs in the Field of Sanitary Engineering Education and subsequently became a co-sponsor with AAPSE.

While compiling the first edition of the jointly sponsored (AAPSE and EEIB) Register, it was agreed that updating about every two years would be necessary if the Register was to serve its intended purpose of providing the profession with a current summary of available educational programs. The second edition (June 1969) was also prepared under the joint sponsorship of AAPSE and EEIB with Professor Dale A. Carlson directing the Educational Resources Committee composed of Professors Gilbert A. Dunstan, Richard S. Engelbrecht, Warren J. Kaufman, H. Nugent Myrick, Cliford W. Randall, and Alan J. Rubin.

OBJECTIVES OF THE REGISTER

The two editions of the Register include information similar to the 1962 Directory and, in addition, contain more detailed information on faculty research, sources of research and student support funds, present enrollment, and the past production of master's and doctor's degrees in the field of environmental engineering. An additional objective has been to measure the impact of federal funds on degree output and to assess the overall influence of the 1960 and 1967 Conferences and the present capabilities of academic institutions in the field of environmental engineering. It is hoped that an analysis and comparison of the data collected in 1965 and 1969 will provide a basis for future planning by both the contributing institutions and by the federal and state agencies responsible for water, air, and other elements of environmental management traditionally associated with sanitary engineering.

The first edition Register questionnaire was initially sent to 85 schools with the stipulation that the published Register would be confined to those programs having two or more full-time sanitary engineering faculty located in a particular department of engineering. A total of 65 schools responded and of these 56 were included in the Register. The few institutions not included that meet the faculty minimum size stipulation did not meet the questionnaire submission deadline. If their original data have been updated, they are represented in the second edition of the Register.

The 1969 Register contains information on 68 schools, and of these 68 two are Canadian institutions. Data from the Canadian schools were excluded from all statistical analyses. Nine of the original 56 did not report changes for the '69 Register. Only 45 of the U. S. schools eligible for inclusion in the Register reported data on enrollment, degrees granted, and sources of student support. The 45 schools are listed in Table 1.

The questionnaire was designed such that a summary of the data would provide a prospective graduate student with enough information to evaluate the program requirements and faculty composition. The questionnaire provided sufficient data to allow an overall evaluation of trends in environmental engineering education. The following analysis generally follows the organization of the 1965 and 1969 questionnaires. Data pertaining to degrees awarded by each institution have not been reported by school, but have been summarized to show trends in growth since 1950.

TABLE 1

SCHOOLS REPORTING ENROLLMENT, DEGREES, AND STUDENT SUPPORT DATA

University of Arizona, Tucson, Arizona
University of Arkansas, Fayetteville, Arkansas
University of California, Berkeley, California
University of California, Davis, California
University of Cincinnati, Cincinnati, Ohio

Colorado State University, Fort Collins, Colorado
Cornell University, Ithaca, New York
Drexel Institute of Technology, Philadelphia, Pennsylvania
University of Florida, Gainsville, Florida
Georgia Institute of Technology, Atlanta, Georgia

University of Hawaii, Honolulu, Hawaii
University of Houston, Houston, Texas
University of Illinois, Urbana, Illinois
University of Iowa, Iowa City, Iowa
Iowa State University, Ames, Iowa

University of Kansas, Lawrence, Kansas
University of Kentucky, Lexington, Kentucky
University of Maine, Orono, Maine
Manhattan College, Bronx, New York
University of Massachusetts, Amherst, Massachusetts

Mississippi State University, State College, Mississippi
University of Missouri, Columbia, Missouri
University of Nebraska, Lincoln, Nebraska
Notre Dame University, Notre Dame, Indiana
University of North Carolina at Chapel Hill, North Carolina

North Carolina State University, Raleigh, North Carolina
Northwestern University, Evanston, Illinois
Ohio State University, Columbus, Ohio
University of Oklahoma, Norman, Oklahoma
Oregon State University, Corvallis, Oregon

Pennsylvania State University, University Park, Pennsylvania
University of Pittsburgh, Pittsburgh, Pennsylvania
Purdue University, Lafayette, Indiana
Rensselaer Polytechnic Institute, Troy, New York
Rutgers - The State University, New Brunswick, New Jersey

Sacramento State College, Sacramento, California
San Jose State College, San Jose, California
Tennessee Polytechnic Institute, Cookeville, Tennessee
University of Texas, Austin, Texas
Tufts University, Medford, Massachusetts

Utah State University, Logan, Utah
Virginia Polytechnic Institute, Blacksburg, Virginia
University of Washington, Seattle, Washington
Wayne State University, Detroit, Michigan
University of West Virginia, Morgantown, West Virginia

PROGRAM TITLES AND OBJECTIVES

Respondents were asked to identify their program technical areas and the objectives of their programs, 100 words being allowed for this purpose. Considering the frequently expressed dissatisfaction with the "sanitary engineering" designation of the field and the tendency to take an "environmental" or "resource" approach to the traditional areas of sanitary engineering, it was believed that asking the participating institutions to state their program titles would provide a useful insight into the present and changing attitudes of educators on the names issue.

Table 2 shows the indicated program titles reported in 1965 and 1969. The number of schools using the "sanitary engineering" title remained relatively constant while the programs including the "environmental" title almost doubled. This increase in "environmental" designations was probably heavily influenced by the change in 1966 of ASEIB to EEIB. A 50 percent increase over 1965 was also noted for the programs using the "water resources" designations, and four programs used "water quality" in describing their activities in 1969 whereas only one had included "water quality" earlier. The "bio" designation was dropped by one of the two 1965 users and it was not adopted by any other school. Of the original 56 schools listed in the first edition Register, 23 had changed the title of their program by 1969. Eleven of the 23 changes involved the elimination of "sanitary engineering" as part of the program title. The majority of the 23 program title changes incorporated "environmental" into their new designation.

TABLE 2

NUMBER OF SCHOOLS USING VARIOUS PROGRAM DESIGNATIONS

Year	Program Titles Used				
	Sanitary Engineering	Environmental	Water Resources	Water Quality	Bio-Engineering
1965	31	18	10	1	2
1969	27	32	15	4	1

Of the twelve new schools added to the Register (1969), 6 indicated program titles that included "sanitary engineering," 5 reported titles including the term "environmental," 2 included "water resources," 2 used "water quality," and one used "water technology." It can be concluded from these data that the often maligned "sanitary engineering" title still remains in use by many schools, but that a majority have now chosen the currently more popular environmental designation while a small group, being wholly committed to water, find the water resources term most acceptable. It is perhaps noteworthy that 8 schools found that sanitary engineering in combination with a newer designation was an acceptable compromise while 16 schools used "sanitary engineering" alone to describe their program. Since developments on the federal scene have a great influence on the profession, including its titles, it will be interesting to follow and correlate federal and institutional designations in the decade ahead. As of October 1969, the only two major federal agencies having the environmental title were the Department of Commerce's "Environmental Science Services Administration," and the Public Health Service's "Environmental Control Administration". None are designated sanitary engineering, and water resources appears rather firmly established in the Department of the Interior.

Somewhat in contrast to the diversity of program titles, 55 of the 68 programs listed in the Registers were located in the Civil Engineering Department. Six schools indicated that their programs were in fact departments having such titles as "Environmental and Sanitary Engineering," "Environmental Sciences and Engineering," "Environmental and Water Resources Engineering," "Environmental Systems Engineering," "Geography and Environmental Engineering," and "Environmental Engineering Science." Only three programs were associated with a chemical engineering department and one of these was a split program with chemical engineering housing the air pollution control program.

A section of the Register questionnaire dealt with the program technical areas and their objectives. This section was difficult to analyze in any quantitative manner, and it seems to reflect the state of flux that exists in the profession in delimiting the scope of the field of sanitary engineering. In identifying technical areas, water and waste treatment remain as the most common of the traditional areas of interest, but are often subordinated to the broader concept of water resources or environmental engineering. A number of schools emphasized systems analysis for integrating the technical elements of the field into the broad planning and management approach and stressed the application of the social as well as the physical and biological sciences, this more often in a resources than environmental context. The term "water resources engineering" appears to imply hydrology and hydraulic engineering, although it was also employed to relate water quality to the management-planning concern for water.

Apart from water, some schools indicated programs in air resources, radiological health, and solid wastes; but again these were depicted in an interdisciplinary light and were often organized interdepartmentally.

It appears to be almost an obsession to describe individual programs in the broadest possible terms, thus assuring the prospective student that all variety of courses and curricular combinations thereof are available. Although specialization is mentioned, as is preparation in the basic sciences, these are clearly undersold in the effort to convey the concept of "specialization in breadth." If one were to select a single phrase to depict the model program description, it might be "environmental science and resources engineering." It is doubtful if many programs live up to this ambitious designation. As noted in the opening paragraph of this analysis, diversity, rather than intensive specialization, is characteristic of the field, especially as it is approached by the university educator.

FACULTIES

The total full-time teaching faculty in the 1965 and 1969 surveys totaled 281, and the number of full-time faculty per program ranged from 2 to 22, with a mean of 5 for both years.

Analyses of the full-time teaching faculty in 56 programs in 1965 and 56 programs in 1969 are shown in Tables 3 and 4. Table 3 shows the distribution of the faculties by rank and certification as professional engineers, diplomates in AAEE, and the number holding doctorates. Unfortunately, data on the number of doctorates was unavailable for the 1969 faculties. Table 4 presents an analysis of the research and professional activity of the sanitary engineering faculty.

The distribution of rank remained relatively constant from 1965 to 1969, and is similar to the results reported by the ASEE Goals Report for all schools. There was a significant decline in the number of AAEE diplomates, and the decline is probably attributable to both the increase in new programs that would have young faculty ineligible for certification and the continuing addition of chemists, biologists, and other disciplines to environmental engineering programs that are also presently ineligible for certification.

It is especially significant that 76 percent of the faculty listed in the 1965 Register held the doctorate (as against 59 percent for all fields, ASEE Goals Report), but that the mean number of years since receiving this degree was only 6.0. The date that each professor received his highest academic degree was reported in the 1965 Register, and the mean value of 6.0 years was obtained by subtracting the degree awarding date for the doctorate holders from 1965, summing these, and then dividing this sum by the number of faculty holding the doctorate. Although the number of faculty holding doctorates was not available for 1969, from personal knowledge and discussion with program leaders it is likely that the number holding doctorates has increased. These data suggest a young, science-oriented faculty with relatively less interest than their older colleagues in the professional accouterments of registration and Academy affiliation.

Although it is not possible to chart precisely the growth of faculty associated with sanitary engineering programs, the questionnaire did inquire as to the date of appointment of the faculty at their present institutions. This information is shown on Figure 1 and gives a reasonably accurate picture of growth. This analysis accounts for 225 of the 281 full-time faculty of which 183, or over 70 percent of

TABLE 3

DISTRIBUTION BY RANK AND CERTIFICATION OF FULL-TIME TEACHING FACULTY

Rank or Affiliation	1965		1969		Distribution of Rank for All Engineering Schools as Reported by ASEE Goals Report (1965)
	Number Full-Time Professorial (56 Schools)	Percentage	Number Full-Time Professorial (57 Schools)	Percentage	
Professor	101	36.0	95	33.8	40
Associate Prof.	85	30.2	97	34.5	32
Assistant Prof.	87	31.0	78	27.8	28
Instructor	8 281	2.8 100.0	11 281	3.9 100.0	--
Registered Eng.	121	43.0	120	42.7	--
AAEE Diplomate	34	12.0	24	8.5	--
Doctorate	214	76.0	--	--	59

TABLE 4

AN ANALYSIS OF THE RESEARCH AND PROFESSIONAL ACTIVITY OF THE SANITARY ENGINEERING FACULTY

Category	1965			1969		
	Number Full-Time Professorial (56 Schools)	Percentages		Number Full-Time Professorial (57 Schools)	Percentages	
		Based on 281	Based[a] on 239		Based on 281	Based[a] on 255
Water and Waste Quality and Treatment	174.0	62.0	72.9	187	66.6	73.3
Systems Analysis	9.5	3.4	4.0	4	1.4	1.6
Hydrology	21.0	7.5	--	13	4.6	--
Hydraulic Engineering and Fluid Mechanics	21.0	7.5	--	13	4.6	--
Air Resources	25	8.6	10.3	29	10.3	11.4
Radiological Health	12	4.3	5.0	8	2.9	3.1
Solid Wastes	4	1.4	1.7	6	2.1	2.4
Other	14.5	5.3	6.1	21	7.5	8.2
Total	281	100.0	100.0	281	100.0	100.0

[a]Omitting 42 and 26 individuals in 1965 and 1969, respectively, in hydrology and hydraulic engineering and fluid mechanics.

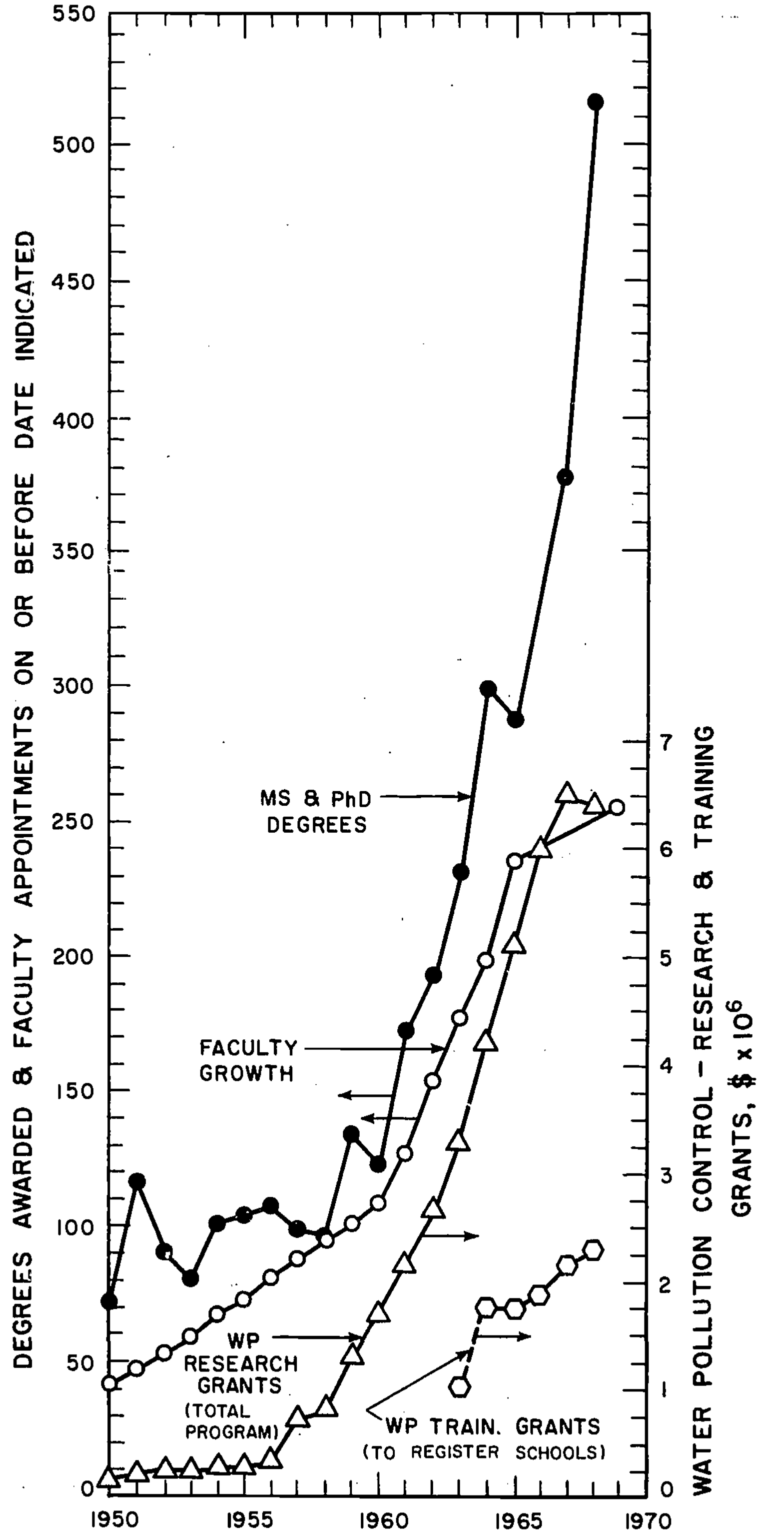

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FIGURE I. ACADEMIC GROWTH & FINANCIAL SUPPORT: SANITARY ENGINEERING - WATER those reporting appointment dates, have moved to their present positions since 1960. The mean number of years since appointment to their present position is 7.1.

In many instances institutions reported faculty as integral to their sanitary engineering programs who were more closely allied with hydraulic engineering and hydrology than with water and waste water quality and treatment. This was more likely to be the case for institutions with broadly organized water resources programs headed by a sanitary engineer who quite naturally saw the entire field as a logical part of sanitary engineering. In other schools, the faculty reported as "in the program" were limited to only those concerned with water and waste water quality and treatment and air resources. In order to make a more accurate assessment of the actual faculty strengths in the various fields of sanitary engineering and those closely related areas, an attempt was made to place the individual faculty into one or two of eight categories; water quality and treatment, systems analysis, hydrology, hydraulic engineering and fluid mechanics, air resources, radiological health, solid waste management, and other. Although each faculty respondent was asked to indicate his teaching and research interests, it was believed that the titles of his three representative publications were more indicative of his true professional or research interest and these were used. Inasmuch as many faculty conduct research in more than one of the indicated categories, such individuals are listed as 50/50 between the most appropriate two categories. The results for 1965 and 1969 are shown in Table 4.

By separating the faculty that clearly have primary interests in hydrology and hydraulics, there remains 239 (1965) individuals in the 56 schools and 255 (1969) individuals in the 57 schools principally concerned with the traditional (c.f., N.R.C. Reports, 1943-57) areas of sanitary engineering. It is believed significant that in 1965 and 1969 nearly three-quarters of these are in the water and waste water field and only 15 percent are in air resources and radiological health combined. Moreover, although these 37 individuals (1965 and 1969) are in sanitary engineering programs, it is doubtful if more than a handful consider themselves sanitary engineers — in the sense of being members of the same profession as their engineering and water quality colleagues.

Care should be exercised in judging the absolute number of university faculty in the water quality field given in Table 4 as correct for the U. S. as a whole. Although a full listing of the schools having sanitary engineering programs would increase this number only slightly, not included are individuals in chemistry and chemical engineering departments and in biology departments who have a principal or partial research interest in water quality and treatment and who may even teach courses in these areas. In fact, it is doubtful whether the Register has identified more than a fraction of the water "scientists" located in U. S. universities and this point should be kept in mind by engineers and administrators making interpretations of the Register.

ADMISSION REQUIREMENTS – DEGREE TITLES

Admission requirements have remained relatively unchanged since 1965. Nearly all schools have established admission requirements based on grade-point averages, these ranging from 2.0 to 3.0 out of a possible 4, but with provisions for waiving the minimum in a majority of instances. About a third of the institutions use the generally higher upper division grades in the major in calculating the applicant's GPA. About 50 percent of the schools report a minimum GPA of 3.0 (or B average), but allow it to be waived. Twenty percent of the schools report minimum acceptable GPA's of 2.7 and a majority of these allow waiving.

It is revealing to analyze the undergraduate disciplines that are admissible to graduate programs in the field of sanitary engineering with often only nominal reported make-up or prerequisite requirements. Although civil engineering and chemical engineering were most often listed, most engineering graduates are admitted without stipulation. Physical science graduates are required in some cases to make up course work in the engineering sciences (e.g., fluids, mechanics, and strength of materials) if they wish to receive an engineering degree but it appears that in a majority of institutions the meeting of undergraduate core engineering requirements is not essential to receiving a graduate degree. These scientists perhaps receive graduate degrees without designation of field. Approximately 50 percent of the schools specifically listed undergraduate biological science as a basis for admission into the graduate program. A few stipulated that biologists would be required to complete make-up work in mathematics or, as an alternate in a few schools, be admitted to environmental science programs rather than engineering. The admissibility of students with undergraduate majors in chemistry was similar to biology.

Although the data on admissions are admittedly sparse, several observations are suggested. A significant fraction (perhaps 20 or 30 percent) of baccalaureate engineering graduates are being encouraged to continue their education, at least through the master's degree, by reducing the minimum GPA for admission to 2.7 or less. Presumably a majority of these students will follow professional careers, rather than careers in research or teaching, and thus should expect to receive a professionally-oriented graduate education. A considerable effort is also being made to attract nonengineers, especially biologists, into these programs. While the association of several disciplines is beneficial, there is the inherent hazard of maintaining adequate course rigor, especially where enrollments are small and common courses must serve several disciplines.

A summary of the titles of the degrees offered is given in Table 5. It is evident that from the standpoint of degree designation, our engineering schools favor the traditional scientific-academic titles of M. S. and Ph. D., with the M. Eng. and Eng. D. running a poor second. In 1965 and 1969 approximately one-third of the schools required a thesis for the master's degree, while in approximately one-half it was reported as optional and about 20 percent reported no thesis requirement. With few exceptions, the residence requirements for the master's degree was reported as the equivalent of about nine months, although it was indicated by many institutions that normally a period of twelve to eighteen months was spent in residence to earn the M. S. degree.

TABLE 5

DEGREES OFFERED BY SANITARY ENGINEERING PROGRAMS REPORTED IN THE REGISTERS

Degree	1965	1969
	Number of Schools Offering	Number of Schools Offering
Master of Science Only	20	21
Master of Science and Master of Engineering (or C.E. Degree)	18	35
Master of Engineering Only	8	0
Master of Public Health or Master of Science in Public Health	1	1
	56	57
Doctor of Philosophy Only	39	45
Doctor of Philosophy and Engineering	3	3
Doctor of Engineering Only	2	0
Doctor of Science Only	3	1
	47	49

The requirements for the doctorate are more difficult to interpret and obviously vary widely from school to school. The residence requirements ranged from one to two years while the normal time for completion ranged from two to four years – but in most cases it was not clear whether this was in addition to the master's year. The unit or course requirements for the doctorate were also highly variable, ranging from no specified requirement to as much as 90 semester units – a value that probably included units taken while obtaining the master's degree.

Language requirements for the doctorate are shown in Table 6. Requirements are variable; however, since 1965 there has been a definite trend toward requiring only one language. The number of schools requiring two languages had dropped from 25 in 1965 to 3 in 1969, and six had eliminated language requirements completely by 1969. Of the three schools offering the Engineering Doctorate, only one language was required, while the Ph. D. degree in the same institution required two.

TABLE 6

LANGUAGE REQUIREMENTS FOR THE DOCTORATE DEGREE

Language Requirement	1965	1969
	Number of Schools Requiring	Number of Schools Requiring
Two Languages	25	3
One or Two Languages (Research tool or greater proficiency substituted for one or both)	6	11
One Language	9	29
None	1	6
Total	41	49

TYPICAL M.S. PROGRAMS

Each participating school was asked to submit a typical M.S. program for inclusion in the Register. Of the 57 U. S. schools submitting current data for the 1969 edition of the Register, 54 schools provided a typical water quality program and 18 submitted a typical air pollution control program.

In an attempt to assess these typical programs, the percentage effort devoted to various areas of endeavor as recommended in the 1967 Report on the Study of Environmental and Sanitary Engineering Graduate Education was used as a base. These recommendations for Water Quality Management Engineering and Air Resources Engineering are shown in Tables 7 and 8.

The mean percent effort in a particular subject area was computed from the sums of the percentages calculated for each school from Register data by interpreting the course titles and do not necessarily reflect the true distribution of effort. At the institutions where theses credit hours were listed in the typical program, the credit hours were classified as an elective. Courses in an engineering category not mentioning either "laboratory" or "design" in the title were classified as "theory" courses. (Perhaps in the next edition of the Register a section showing the distribution of effort in each subject area can be included.) It is recognized that such a classification system as described above is highly arbitrary; however, regardless of the obvious limitations of the classification system and the Register data, some indication of a national trend should be obtainable from the mean values for all reporting schools. The mean distributions of the percent effort in various study areas are shown in Tables 7 and 8.

Examination of Table 7 shows that there is a wide range of effort in the various study areas; however, the mean effort shows a trend toward agreement with the recommended distribution of effort for water quality programs. There is a slightly greater variation between the means and recommended effort in the air resources program, but in general there is a trend toward agreement.

It would be pure conjecture to state that the mean percent effort in each category in either of the programs reflects the actual distribution of effort; however, it would be expected that course titles reflect somewhat the course content. The distribution of effort reported in Tables 7 and 8 are at best crude estimates, but the results tend to show that as a group, programs are being conducted that approximate the efforts recommended by a concensus of educators and practitioners in the field of Environmental Engineering.

TABLE 7

DISTRIBUTION OF EFFORT IN STUDY AREAS FOR
WATER QUALITY MANAGEMENT ENGINEERING

Number of Schools Reporting Courses in Each Category		Range of Effort %	Mean (Based upon 54 Schools) %	Recommended Distribution of Effort %
Engineering				
Theory	54	9.1 → 67.6	37.3	20
Laboratory	19	0 → 26.7	4.1	10
Design	30	0 → 20.0	5.0	10
Chemistry	37	0 → 30.0	9.9	15
Biology	49	0 → 33.3	12.9	15
Systems Analysis Math., Statistics	31	0 → 40.1	9.7	15
Electives (Including thesis where required)	50	0 → 57.1	19.2	15

TABLE 8

DISTRIBUTION OF EFFORT IN STUDY AREAS FOR
AIR RESOURCES ENGINEERING

Number of Schools Reporting Courses in Each Category		Range of Effort %	Mean (Based upon 18 Schools) %	Recommended Distribution of Effort %
Air Pollution Engineering	18	20 → 59.5	36.6	25
Physics	3	0 → 12.9	1.6	10
Meteorology	11	0 → 25.4	7.4	10
Environmental Health	6	0 → 12.1	2.9	10
Chemistry	15	0 → 30.0	11.5	10
Biology	8	0 → 20.0	4.0	10
Systems Analysis, Math., Statistics	10	0 → 20.0	6.7	10
Electives (Including thesis where required)	18	0 → 42.2	25.5	15

DEGREES AWARDED AND PRESENT STUDENT ENROLLMENT

One of the most important aims of the Registers was to establish the level of productivity of sanitary engineering programs and to identify the specialty areas in which sanitary engineers are being educated. Participating institutions were asked to enumerate by categories the master's and doctor's degrees awarded each year since 1965 and to indicate the number of degrees awarded to foreign nationals. The results were added to the 1965 Register data and are shown on Figure 2 for master's and doctor's degrees related to water quality and master's plus doctor's degrees related to air resources engineering. The totals reported for 1969 represent data from 45 of a potential 68 schools eligible for the 1969 Register. The totals in three categories: water, air, and radiological health, are summarized in Table 9 for the full period of record, 1950-1969, and for the periods 1960-1965, and 1966-1969, during which new programs were developed under primarily federal sponsorship. The degrees awarded to non-U. S. nationals amounted to about 15.5 percent of the totals. It appears that some of the data received represented more of an institutional effort than a departmental effort as was requested. This was particularly true in air resources and radiological health categories.

The data presented in Figure 2 and Table 9 include some non-engineers, especially in more recent years, and it is not entirely clear the extent to which these should be placed in the water science and engineering category. Some individuals majoring in hydraulic engineering and hydrology are undoubtedly also included as are a few sanitary scientists or sanitarians. However, recognizing that several schools are not represented it is believed that these data are conservative estimates of the yearly U. S. production of graduate level degrees in the water quality and treatment field, including waste treatment and pollution control, over the past nineteen years.

Of the 124 foreign students receiving graduate degrees between 1966 and 1969, only 27 returned to their native country. It would appear that we are hindering progress in undeveloped areas by retaining their brighter citizens after graduation.

Table 10 shows a detailed analysis of the masters and doctors degrees awarded during 1966-67 and 1967-68 as to degree designation, field in which the first degree was received, and the EEIB speciality designation under which the degree was obtained. It is interesting to note that the number of degrees awarded in the various

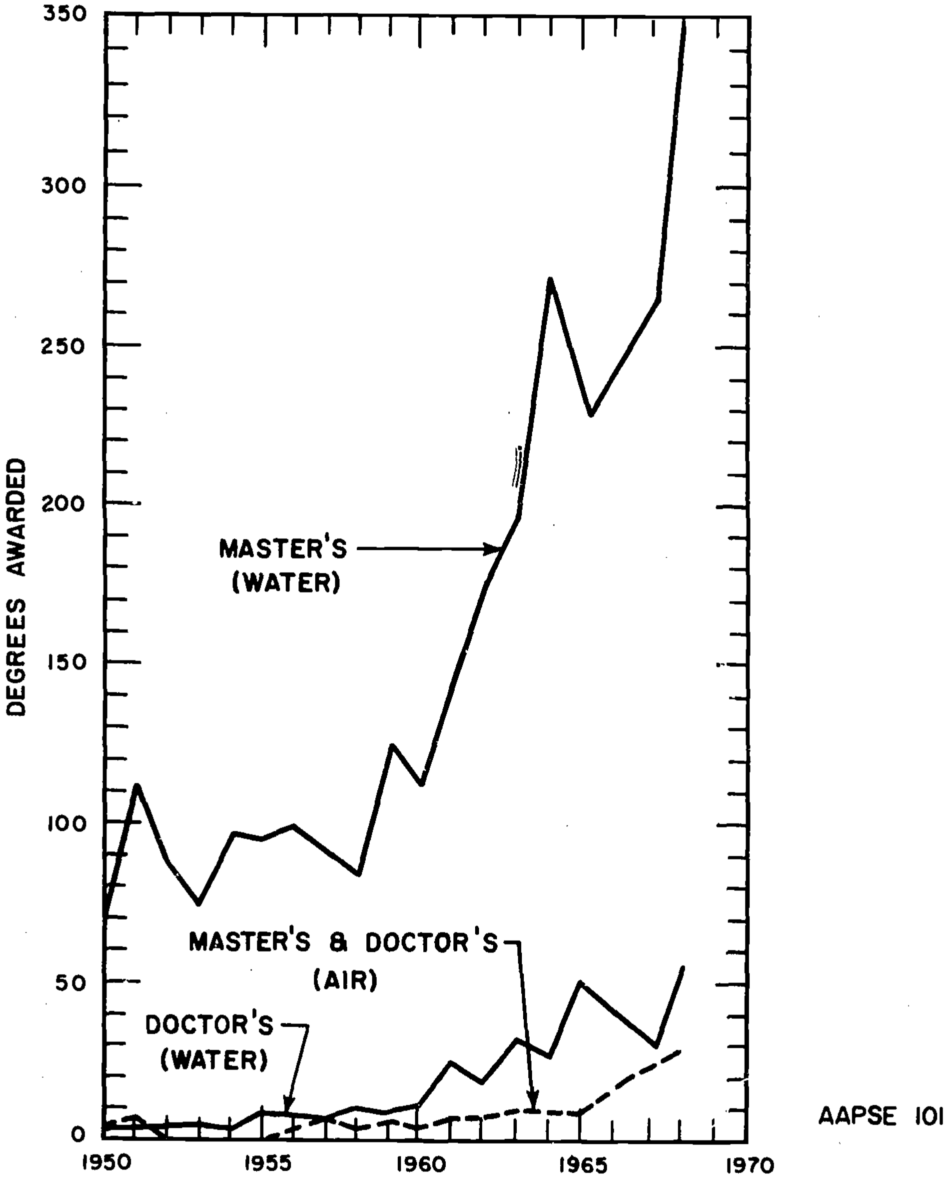

FIGURE 2. DEGREES IN SANITARY ENGINEERING: WATER & AIR

TABLE 9

DEGREES AWARDED IN SANITARY ENGINEERING
(56 U.S. Schools, 1965, and
45 U.S. Schools, 1969)

Category	1950 - 1965		1960 - 1965		1966 - 1969	
	M.S.	Ph.D.	M.S.	Ph.D.	M.S.	Ph.D.
Water Quality and Treatment[a]	2,077	228	1,144	163	636	84
Air Resources	66	14	38	10	59	12
Radiological Health	46	6	49	12	44	21

[a]Includes non-U.S. nationals. Totals for M.S. and Ph.D. were: 1950-1965: 361 (or 15.7%); 1960-1965: 200 (or 15.2%); 1966-1969: 124 (or 12.0%).

EEIB speciality designations closely corresponds to the distribution of the full-time faculty. Approximately three-fourths of all the degrees awarded could be classified as water quality degrees. Based upon the two years reported, it appears that the number of biologists enrolling in water quality programs is increasing significantly.

In order to compare the degrees awarded in sanitary engineering related to water to those in all of engineering through 1965, Figure 3 has been prepared utilizing data from the ASEE Goals Report of October 1965. The trendlines of growth are shown together with their annual rates of growth in percent per year. Data for the number of degrees granted were submitted by only 45 of the potential 66 schools eligible for the 1969 Register. Therefore, to obtain a more accurate estimate of the number of degrees granted, the number granted by the 45 institutions reporting was multiplied by the ratio of 66 to 45, or 1.47 which gave an estimate of 406 and 529 master's degrees granted in 1966 and 1967, respectively, and 43 and 81 doctor's degrees from the same years. As the ASEE Report data covered the period up to 1960, it has been extended to 1968 with more recent statistics.* It is noteworth that prior to about 1959 or 1960 the increase

*Preliminary Report by Engineering Manpower Commission of Engineers Joint Council on Engineering Graduates and Job Prospects (1969).

TABLE 10

DEGREES AWARDED IN ENVIRONMENTAL ENGINEERING 1966-67 AND 1967-68 ACADEMIC YEARS

	EEIB Speciality Designations†									
A. Degree	Sanitary Engineering				Industrial Hygiene Engineering		Air Poll. Control Engineering		Radiation and Hazard Control Engineering	
1. Degree Designated: a. First Degree Field	Water Qual. Management Engineering		Solid Wastes Engineering							
	66-67	67-68	66-67	67-68	66-67	67-68	66-67	67-68	66-67	67-68
A. Master's										
1. Science (MS): a. Engineering*	170	228	2	16	-	2	13	19	14	9
b. Biology*	40	64	-	1	1	-	1	-	4	6
c. Chemistry*	8	5	-	-	-	-	8	4	5	6
2. Engineering	46	46					1	2		
3. Other (specify): a. Engineering*	10	14	1	5	1	1	4	4		
b. Biology*	1	2	1	1	1	1	1			
c. Chemistry*	1	1	1				1	1		
Totals	276	360	5	23	3	4	29	30	23	21
Percentage of Total Master's Degrees Awarded	82.1	82.2	1.5	5.3	0.9	0.9	8.6	6.8	6.9	4.8
B. Doctor's										
1. Philosophy: a. Engineering*	28	46			1	1	4	8	6	11
b. Biology*		4								
c. Chemistry*	1	5							2	2
Totals	29	55			1	1	4	8	8	13
Percentage of Total Doctoral Degrees	69.0	71.4			2.4	1.3	9.5	10.4	19.1	16.9

*First degree field of individuals receiving master's or doctor's degree. The purpose here is to indicate both the degree received (e.g., A. 1. Master of Science) and the speciality area of the first college degree received (e.g., A. 1. c., B.S. in Chemistry).

†1 July through 30 June.

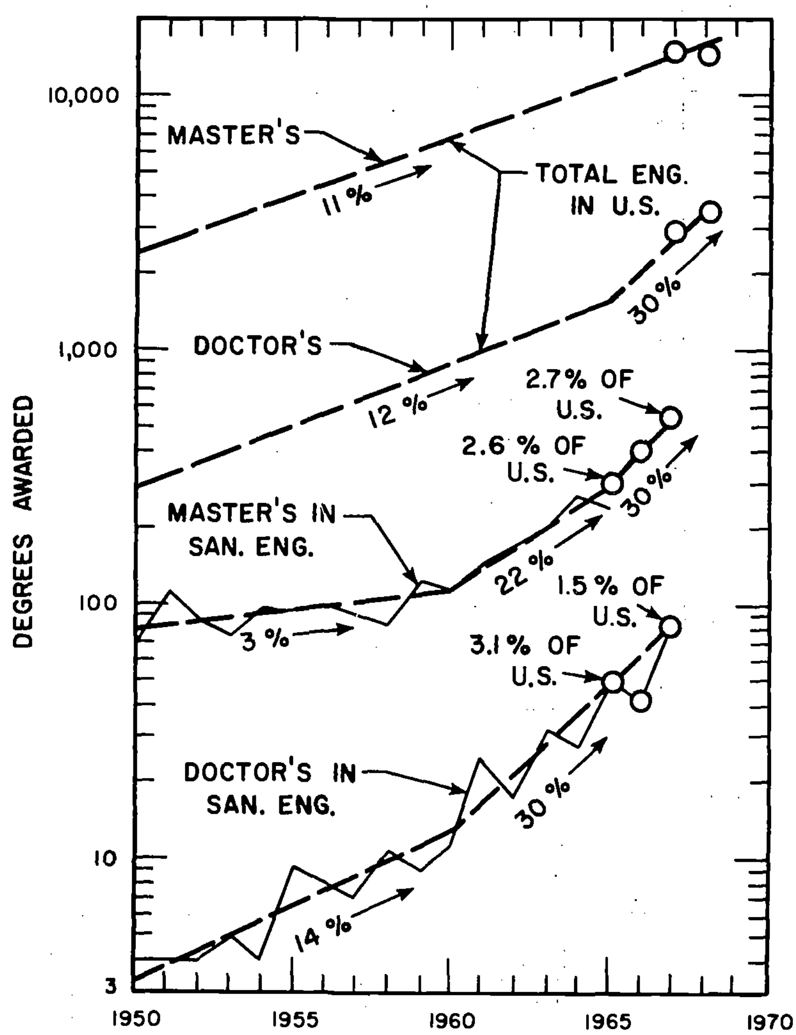

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FIGURE 3. GRADUATE DEGREES: TOTAL ENGINEERING & SANITARY ENGINEERING - WATER

in master's degrees in water quality (or, for all practical purposes, in sanitary engineering) was only 3 percent per year compared to the national average of 11 percent. However, in the 1960-1965 period, the growth increased to double the national average and has continued to increase at approximately the same rate since 1965. The doctorate growth also increased sharply in 1960 such that it was over twice the national average rate in 1965. However, by 1967 the doctoral growth rate in all engineering programs had matched the production rate (30 percent) in sanitary engineering (water quality). The 1967 production of master's degrees in sanitary engineering was 2.7 percent of the national total, and for the doctor's degrees it was 1.5 percent of the 1967 national total.

Figure 1 shows the total of the master's and doctor's degrees awarded each year in sanitary engineering — water, the yearly total awards of Federal Water Supply and Pollution Control (WP) research grants, together with recent WP training grant awards to the Register schools, and faculty growth at these schools. It appears that 1960 was a pivotal year and that faculty growth and degree productivity bear a close correspondence, through 1965 both reflecting the increase in research and training support of the late fifties and early sixties. Following 1965 the faculty growth rate declined to a level approximately equivalent to the rate of growth prior to 1960 and differed considerably from the rate of increase in degrees awarded. This decrease in faculty growth with respect to the rate of degree production is a logical development in the light of the number of student vacancies in programs initiated during the early 1960's. It is probable that there will be a further decline in the ratio of the rate of faculty growth to rate of increase in degrees granted as more programs approach full capacity.

An effort was made to relate individual school degree productivity with 1963-1968 WP training support but with poor correlative results, probably because many recently expanded programs are yet to reach full production. Also to be considered is the fact that many water supply and pollution control programs have received environmental science grants, public health graduate training grants, environmental health traineeship grants, as well as water supply and pollution control fellowships, none of which were considered in the correlation. Since 1966 there has been essentially no increase in the monies granted to universities for research while the number of programs eligible for such funds has increased significantly. With the recent upsurge of interest in preserving the environment, many new and varied disciplines have requested and received research and training funds which has resulted in the same amount of money being distributed to a much larger group. This fact combined with substantial increases in overhead allowances has resulted in substantial reduction in actual research and training funds as far as established programs are concerned.

In 1968, only 13 percent of the funds in the Research Contracts Program of the Federal Water Pollution Control Administration (now FWQA) were awarded to universities; therefore, these funds have done very little to offset the decrease in Research Grants. It appears that with the increased emphasis on Demonstration Grants and Contract Research that the Federal Water Quality Administration research money is being substantially diverted from one of the best trained and experienced research organizations in the world. The Demonstration Grants and Contract Research Programs are worthy of support; however, these programs should be developed independently of the Research Grants Program so that growth is not hindered in any of the programs. With the increasing number of problems being imposed upon the environment by waste discharges, it seems unwise to impede progress in any area of endeavor that offers a great potential to provide new and unique solutions to environmental problems.

Although the research funds available through the Bureau of Water Hygiene, Environmental Control Administration, for water supply research are not improperly distributed, the funds are grossly inadequate and do not reflect the federal responsibility for protecting the public health. Training support in water supply is for all practical purposes nonexistant. It would appear that the Congress should be more cognizant of the needs of the nation in this area and make every effort to significantly increase appropriations for water supply training and research.

Another aspect of degree productivity is the distribution of degrees awarded among the reporting schools, this being especially significant for the master's degree. A cumulative frequency analysis was made for the 1965, 1966, and 1967 academic years by ranking each school by degrees produced and dividing by the number of schools responding plus one. Fifty-six schools responded in 1965 but only 45 reported degree production in 1966 and 1967. The results are shown in Figure 4. In 1965, 18 percent of the schools awarded no master's degrees in sanitary engineering (water quality) and 50 percent of the schools awarded less than four master's degrees, while the maximum number of degrees awarded by any one school was twenty. By 1966, the schools awarding no master's degree in sanitary engineering (water quality) had dropped to 11.6 percent and 50 percent of the schools awarded five or more master's degrees, while the maximum number of degrees awarded by one school was eighteen. In 1967, the schools not awarding a master's degree in sanitary engineering (water quality)

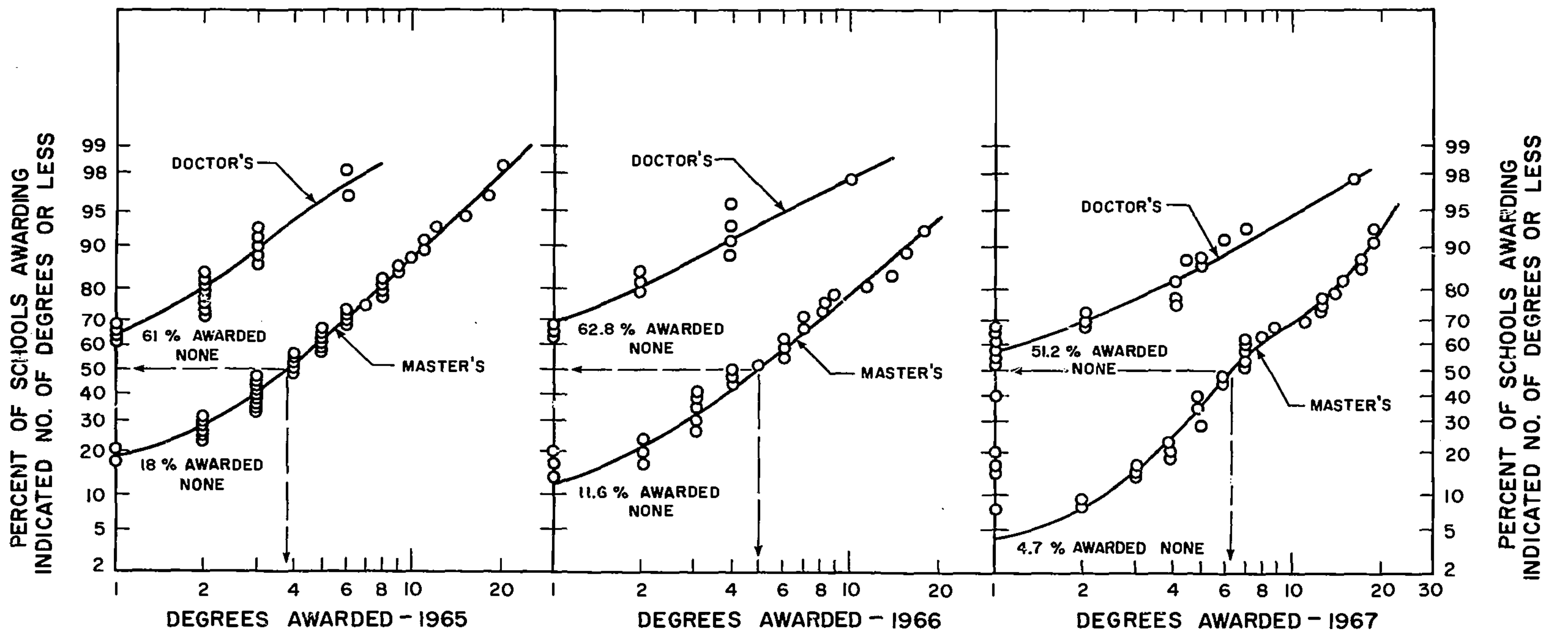

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FIGURE 4. DISTRIBUTION OF DEGREES AWARDED DURING 1965, 1966, & 1967 ACADEMIC YEARS SANITARY ENGINEERING - WATER

had dropped by 60 percent to a low of 4.7 percent and 50 percent of the schools were awarding over six master's degrees, and the maximum number of degrees awarded by one school was nineteen. This rapid decline in the schools not awarding master's degrees indicates that most of the new programs are now producing graduates, and that the number of new programs being developed has also declined. Only 39 percent of the schools awarded doctorates in 1965, and the number awarding doctorates dropped to 37 percent in 1966. Apparently, by 1967 several of the new programs were producing doctoral graduates because the schools awarding doctorates had increased to 49 percent of the 45 schools reporting. The increase in production of doctorates in the newer programs is even more apparent when it is considered that the 45 schools submitting data do not include many of the long established doctoral programs. Another interesting statistic is the increasing emphasis on doctoral level education (c.f., growth rates in Figure 3), with the ratio of doctor's degrees to total degrees awarded increasing from about 0.06 in 1950-1955 to about 0.15 in 1965, and this ratio has fluctuated between 0.34 and 0.15 since 1965.

In the Register questionnaire, participating institutions were asked to indicate their present enrollments of post-bachelor, and post-master students and to show the specialty category of each group as well as the full- and part-time enrollment. The total enrollments for 1965 and 1969 are shown in Table 11. The totals shown for 1969 represent only 45 schools out of a potential 66 schools. In both 1965 and 1969, approximately 80 percent of the total enrollment in the post-bachelor's programs was principally concerned with water quality. The post-master's enrollment was composed of 78 and 73 percent water quality—oriented personnel in 1965 and 1969, respectively.

In Figure 5 are shown the distributions of full-time post-bachelor's (i.e., master's) and post-master's (i.e., doctoral) enrollments in all categories for the forty-five participating schools. It is noteworthy that all of the schools reported post-bachelor's and 20 percent reported no post-master's enrolled. The mean post-bachelor's enrollment was 13.5 and the post-master's, 7.9 candidates based upon the total enrollment in environmental engineering.

Figure 6 shows the distribution of enrollment in EEIB specialties for January-February 1969 at the 45 schools reporting. Although the totals for the 45 schools do not reflect the total enrollment in environmental engineering, the distribution probably is a good estimate for the 66 U.S. schools known to be eligible for inclusion in the Register.

One question that is invariably asked in rating an academic program is what is the ratio of students to faculty. If the ratio is large, legislatures are pleased to find the faculty heavily concerned

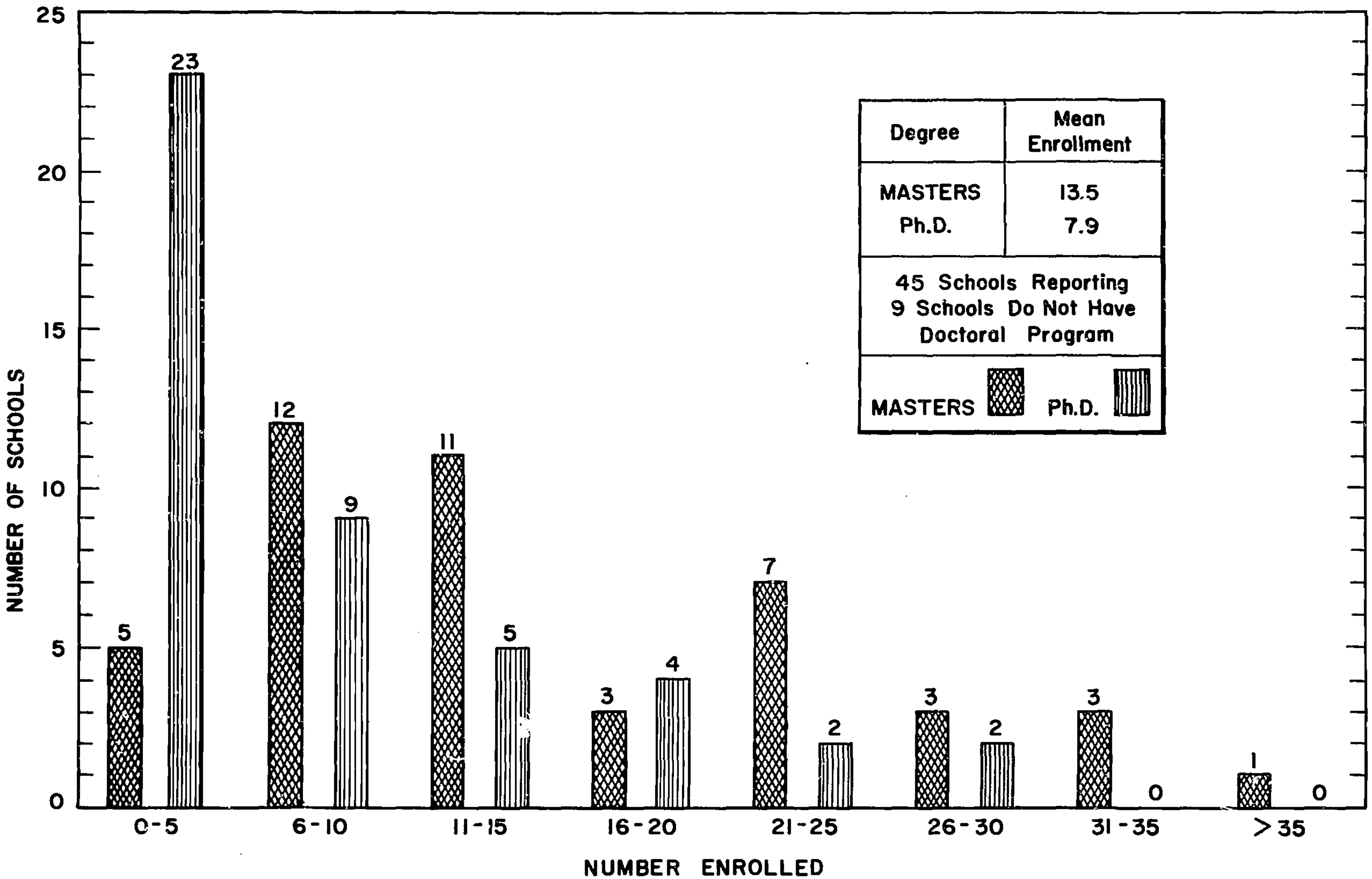

FIGURE 5. DISTRIBUTION OF ENROLLMENTS FOR JANUARY - FEBRUARY 1969

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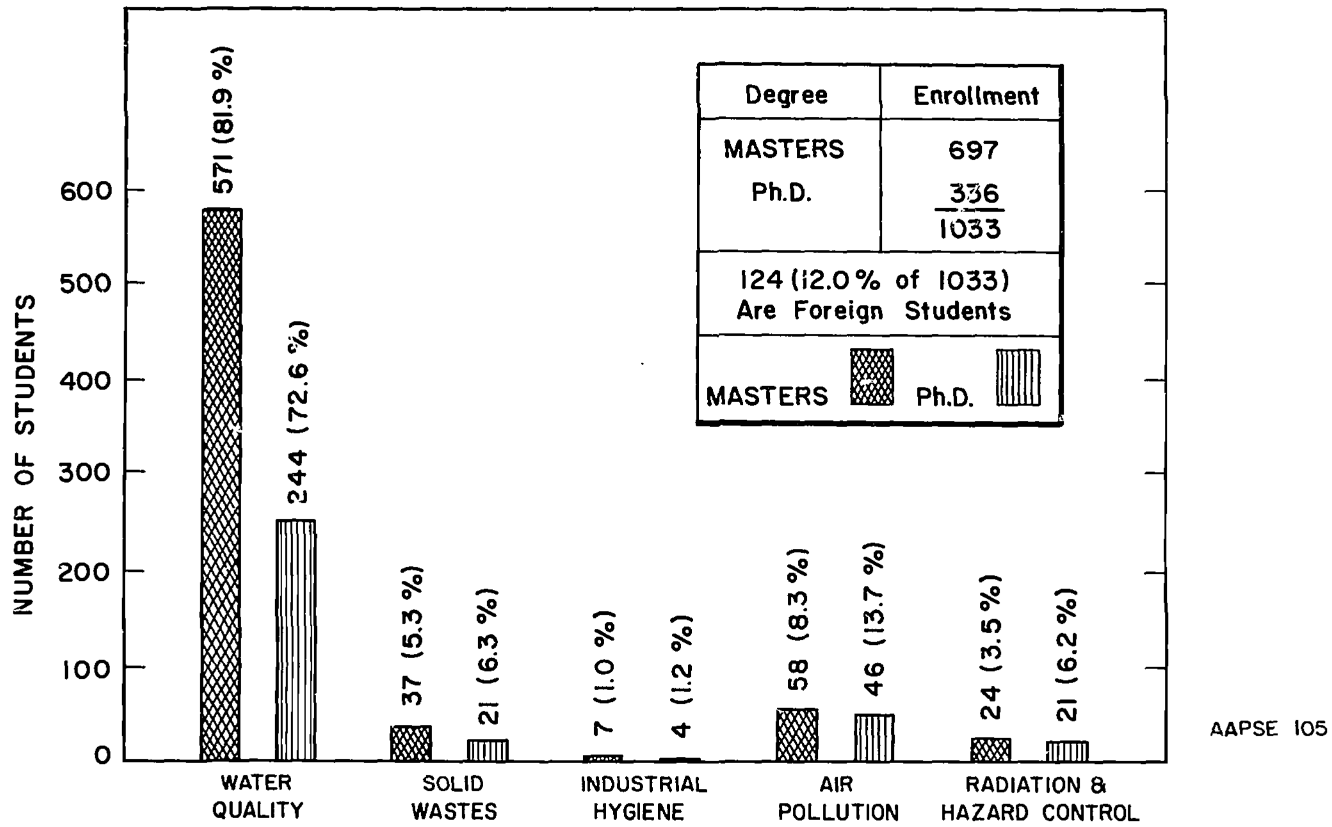

FIGURE 6. DISTRIBUTION OF ENROLLMENT IN SPECIALTIES FOR JANUARY-FEBRUARY 1969

TABLE 11

ENROLLMENT IN ENVIRONMENTAL ENGINEERING PROGRAMS
1965-1966 (56 SCHOOLS) AND 1968-1969 (45 SCHOOLS)
ACADEMIC YEARS

Category	Post-Bachelors				Post-Masters			
	Part Time		Full Time		Part Time		Full Time	
	1965	1969	1965	1969	1965	1969	1965	1969
Total, All Categories	140	189	595	508	32	55	352	281
Estimated -- Water Quality	125	159	459	412	27	41	270	203

with what is supposed to be their principal responsibility; teaching. If the ratio is small, the professors (and especially the deans) are proud of the individual attention their students are presumably receiving and claim a high-quality program. In the case of the Register respondents, it is possible to estimate the ratio of full-time students in sanitary engineering—water to full-time sanitary eingineering—water faculty. However, the interpretation of the results of the calculation should be made with caution as many of the faculty teach undergraduate courses and many of their students may not be graduate students in sanitary engineering. The mean student-faculty ratio and ranges are shown in Table 12 for 1965 and 1969. It appears that there has been an increase in the student to faculty ratio since 1965. This is probably attributable to the increase in enrollment in many of the new programs which reported very low ratios in 1965. It is also possible that the inclusion of data from all schools would reduce the 1969 ratio to the previous level. As a further cautionary consideration, schools with large doctoral enrollments would be expected to have smaller student-faculty ratios than those with predominantly master's programs; although this does not appear to be the case.

Perhaps the most significant observation to be drawn from Figures 4 and 5 is that the median number of master's degrees awarded

TABLE 12

RANGES AND MEAN STUDENT – FACULTY RATIOS

Student – Faculty Ratio	Number of Schools	
	1965 (56 Schools)	1969 (45 Schools)
≦ 3.0	24	18
≧ 5.0	12	15
≧ 8.0	6	8
Range for all schools	1.0 - 15	1.6 - 35
Mean	4.4	6.3

in water quality–oriented education programs has gradually increased from 4 to over 6 per year per program, this resulting from a median enrollment of 7.5 (i.e., 9.5 x 0.80) in 1965 and 10.8 in 1969.

INITIAL EMPLOYMENT OF 1966-67 and 1967-68 DEGREE RECIPIENTS

The distribution of the initial employment accepted by 1966-67 and 1967-68 degree recipients is shown in Table 13. More than one-third of the master's degree recipients and one-sixth of the doctor's degree recipients accepted employment with some governmental agency in both years. It is interesting to note that in both years a greater percentage of the master's and doctor's degree recipients were employed by consulting firms than the federal government. Teaching positions were accepted by a large percentage of the doctor's degree recipients; however, in 1967-68 there was a definite decline in the number going into teaching. This is probably due to the maturation of most of the existing programs and a decrease in emerging programs.

TABLE 13

INITIAL EMPLOYMENT OF DEGREE RECIPIENTS IN ALL FIELDS

Area of Employment	Master's		Doctor's	
	66-67	67-68	66-67	67-68
Federal Government	15.8%	17.3%	14.3%	9.2%
State Government	14.5%	13.9%	0.0%	7.9%
Municipal Government	3.3%	5.7%	2.4%	0.0%
Consulting	16.3%	18.9%	14.3%	15.8%
Continuing Education	20.7%	17.2%	0.0%	1.3%
Industry	13.0%	10.9%	9.5%	13.2%
Armed Forces	5.7%	8.9%	2.4%	5.3%
Teaching	3.6%	2.8%	57.1%	40.7%
Left the Field	0.0%	0.5%	0.0%	0.0%
Other	7.1%	3.9%	0.0%	6.6%

The effect of changes in draft laws is reflected in the increase in 1967-68 in the percentage of master's and doctor's degree recipients entering the armed forces. There was a slight decline in the percentage of master's degree recipients continuing their education which was probably also a result of changes in draft laws.

A detailed distribution of the number of graduates accepting initial employment with various groups within the broad areas given in Table 13 is shown in Table 14 according to EEIB specialty designations.

TABLE 14

INITIAL EMPLOYMENT OF 1966-67 AND 1967-68 DEGREE RECIPIENTS[a]
(March 1, 1969)

Area of Employment	EEIB Specialty Designations									
	Sanitary Engineering				Industrial Hygiene Engineering		Air Pollution Control Engineering		Radiation and Hazard Control Engineering	
	Water Qual. Management Engineering		Solid Wastes Engineering							
	66-67	67-68	66-67	67-68	66-67	67-68	66-67	67-68	66-67	67-68
A. Master's										
1. Federal Government										
a. FWPCA	13	6		2	1		1	1	2	3
b. HEW	23	37		3			5	4	2	3
c. Other	5	15					1	1		1
2. State Government										
a. Public Works and Water Resources	12	18		2			1	1	3	4
b. Public Health	22	27					1	3	1	
c. Other	3	2				1	5	2		1
3. Municipal Government and Utility Districts	10	20		2			1	2		1
4. Consulting	51	78		2			2	2	1	1
5. Continuing Education (e.g., for Ph.D.)	57	63	2	3			5	7	5	2
6. Industry										
a. R & D	28	31	1	5		1	6	6	3	1
b. Sales Engineering	2	4					1			
c. Management	2									
7. Armed Forces	18	31	1	4				1		3

TABLE 14 (Continued)

Area of Employment	EEIB Specialty Designations									
	Sanitary Engineering				Industrial Hygiene Engineering		Air Pollution Control Engineering		Radiation and Hazard Control Engineering	
	Water Qual. Management Engineering		Solid Wastes Engineering							
	66-67	67-68	66-67	67-68	66-67	67-68	66-67	67-68	66-67	67-68
8. Teaching	11	10					1			2
9. Left the Field		2								
10. Other	19	12					1	1	4	4
Total	276	356	4	23	1	2	30	32	21	26
B. Doctor's										
1. Federal Government										
a. FWPCA	3	1								1
b. HEW	1	1						1		1
c. Other	1	1						1	1	
2. State Government										
a. Public Works and Water Resources										
b. Public Health		3								
c. Other		2								1
3. Municipal Government and Utility Districts	1									
4. Consulting	4	11					2			1
5. Continuing Education (post doctoral)		1								

TABLE 14 (Continued)

Area of Employment	EEIB Specialty Designations									
	Sanitary Engineering				Industrial Hygiene Engineering		Air Pollution Control Engineering		Radiation and Hazard Control Engineering	
	Water Qual. Management Engineering		Solid Wastes Engineering							
	66-67	67-68	66-67	67-68	66-67	67-68	66-67	67-68	66-67	67-68
6. Industry										
a. R & D	1	5				1		3	2	1
b. Sales Engineering										
c. Management					1					
7. Armed Forces	1	3						1		
8. Teaching	17	24					2	2	5	5
9. Left the Field										
10. Other		3								2
Total	29	55			1	1	4	8	8	12

[a]Includes data from 45 schools listed in Table

Total Doctoral Degrees Awarded 66-67 = 42
Total Doctoral Degrees Awarded 67-68 = 76

Total Master's Degrees Awarded 66-67 = 332
Total Master's Degrees Awarded 67-68 = 439

FINANCIAL SUPPORT

The total students receiving financial support in all fields in 1965 for the 56 schools reporting was 928, and this had increased to 1,033 for the 45 schools reporting in 1969. Since only 45 schools reflect an increase over 1965, apparently far more students are being supported in graduate programs in environmental engineering. As the part-time students are included, and as many of these presumably have off-campus employment, the percentage of full-time students receiving support (administered by the institutions) is probably greater than 90 percent. The mean number of students supported per school program is 23.0, but the students supported by individual schools ranged from 7 to 77. A breakdown of the sources of student support is shown in Table 15.

TABLE 15

SOURCES OF STUDENT SUPPORT IN ALL FIELDS REPORTING

	1965	1969
Federal Research and Training Grants (FWPCA, PHS, NSF, OCD, AID)	80.4%	59.1%
State (State University Funds and State Agencies)	10.9	5.4[a]
Industrial, Private Foundations, and Private Universities	5.8	11.3[a]
Foreign Government	0.9	2.1
International (WHO)	0.3	1.2
Individual or Personal	1.3	11.3
Unidentified	0.4	2.8
Total Supported	928 (56 Schools)	1,033 (45 Schools)

[a]State agencies (5.5) and private industry (11.7) not including universities. All university support was 6.8%.

Because of the manner of reporting in 1965, it was not possible to identify the support with respect to the field of the student, but it is believed that the distribution shown in Table 15 for all fields is reasonably applicable to sanitary engineering—water. In 1969 the method of reporting was changed to include the field of interest along with the source of support, and this information is shown in Table 16. Only 55 percent of the total support for water quality management programs was obtained from the federal government. However, for the other specialty areas federal support comprised a much greater percentage of the total and ranged from 67 percent for solid wastes programs to 91 percent for radiation and hazard control. It is interesting to analyze the origin of student support for the five schools having the highest full-time enrollment. This analysis is shown in Tables 17 and 18.

It might also be noted that in the ASEE Goals Report (c.f., Table D-13) graduate fellowships for all categories of engineers were supported 50 percent by private funds, 15 percent by state and local funds, and only 35 percent from federal sources. The latter figure was about half of that for the fields of sanitary engineering in 1965 but had increased to two-thirds by 1969.

Other sources of support, including research grant support, have not been analyzed in detail. However, a few examples of the recent support situation might be enlightening and serve to supplement the data r esented in Figure 1. The sources of this information are the Federal Water Quality Administration and the September 1965 Status Report, Environmental Health Sciences Training Programs prepared by the Office of Resource Development, Bureau of State Services, PHS. Water pollution training grant awards for sanitary engineering and nonsanitary engineering programs in the schools reporting enrollment data are given in Table 19 together with the total training grant awards for the same period. Of the 45 schools reporting enrollment statistics, twelve did not receive a training grant from the FWQA.

The training grant expeditures for water pollution have been a combination of PHS and FWPCA (FWQA) funds for the past five or six years because of the transfer of responsibility for water pollution control to the Department of the Interior. Because of the difficulty in separating and allocating the PHS training grants, only the FWPCA training funds are shown in Table 19 for 1966-1968. The sources of student support (Table 16) derived from 1968 federal funds were reported according to the granting agency, which made it possible to estimate a mean cost per year of $8,600 to the FWPCA for educating one student. Although all federal programs provided 55 percent of the

TABLE 16

SOURCES OF STUDENT SUPPORT FOR ENVIRONMENTAL ENGINEERING EDUCATION[a]
(January-February 1969)

Support Source	EEIB Specialty Designations									
	Sanitary Engineering				Industrial Hygiene Engineering		Air Pollution Control Engineering		Radiation and Hazard Control Engineering	
	Water Qual. Management Engineering		Solid Wastes Engineering							
	Mast.	Doct.	Mast.	Doct.	Mast.	Doct.	Mast.	Doct.	Mast.	Doct.
1. FWPCA										
a. Training Grant	137	31	0	0	0	0	1	0	0	0
b. Research Fellowship	6	13	0	0	0	0	0	0	0	0
c. Research Grant or Contract	22	19	0	3	0	0	0	0	0	0
2. Public Health Service										
a. Training Grant	55	38	21	3	5	1	34	22	15	21
b. Research Grant	6	4	2	2	1	0	1	3	0	0
c. Training Leave from PHS	3	2	4	1	0	0	4	1	0	0
d. Other	2	3	0	0	0	0	0	3	0	0
3. Office of Water Resources Research	33	21	0	0	0	0	0	0	0	0
4. National Science Foundation										
a. Training Grant or Stipend	4	4	0	1	0	0	0	0	0	0
b. Research Grant	2	1	0	0	0	0	0	0	0	0
5. Department of Defense										
a. Research Contracts	3	1	0	0	0	0	0	0	0	0
b. Military Pers. on Train. Leave	13	3	0	0	1	0	2	1	5	0
6. Other Federal Agencies	17	6	0	2	0	0	0	2	0	0
7. Stage Agencies										
a. Training Grant	2	3	0	2	0	0	0	0	0	0
b. Research Grantor Contract	15	2	0	0	0	0	0	0	0	0
c. Training Leave from State Agency	28	4	0	0	0	0	0	0	0	0

TABLE 16 (Continued)

Support Source	EEIB Specialty Designations									
	Sanitary Engineering				Industrial Hygiene Engineering		Air Pollution Control Engineering		Radiation and Hazard Control Engineering	
	Water Qual. Management Engineering		Solid Wastes Engineering							
	Mast.	Doct.	Mast.	Doct.	Mast.	Doct.	Mast.	Doct.	Mast.	Doct.
8. Industrial										
a. Training Fellowship	2	0	0	1	0	1	1	3	0	0
b. Research Grant or Contract	7	2	0	0	0	0	2	0	0	0
c. Industrial Employment with Part-Time School	72	12	5	2	0	0	2	4	1	0
9. University										
a. Scholarships	3	3	0	0	0	0	0	0	0	0
b. Research Assistantships (University Funds)	15	12	0	0	0	0	1	0	0	0
c. Teaching Assistantships	12	20	1	2	0	1	0	0	0	0
10. World Health Organization	11	1	0	0	0	0	0	0	0	0
11. Foreign Governments	17	4	0	0	0	0	0	0	1	0
12. Other Sources of Support	19	7	1	1	0	0	0	0	0	0
13. Individual Self-Supported (i.e., no employment or grant)	65	28	3	1	0	1	10	7	2	0
Total Number of Students	571	244	37	21	7	4	58	46	24	21
Total Number of Full-Time Equivalent Students[b]	428	211	35	20	7	4	49	39	22	21

[a]Includes data from 45 schools.

[b]A full-time equivalent student is an individual devoting his entire time to graduate study and/or carrying a course-research load equal to that of the full-time student.

TABLE 17

ORIGIN OF SUPPORT IN PROGRAMS HAVING HIGHEST 1969 ENROLLMENTS

School	Students Supported				
	Fed.	State	Ind. Private Found.	Foreign Govt.	WHO
A.	53	7	0	2	3
B.	36	0	1	4	0
C.	43	0	1	0	2
D.	37	1	1	1	0
E.	23	9	7	0	0

TABLE 18

DISTRIBUTION AND NATURE OF FEDERAL SUPPORT TO PROGRAMS HAVING HIGHEST 1969 ENROLLMENTS

School	Student Support				
	Lab. Asst.	Res. Grants	Traineeships FWPCA & PHS	PHS or Military Officers	NSF
A.	0	12	30	3	1
B.	0	4	23	4	4
C.	3	0	35	6	0
D.	1	1	31	5	0
E.	0	2	19	1	0

TABLE 19

WATER POLLUTION TRAINING GRANT AWARDS

Year	Institutions Reporting Enrollment Data				Total Training Grant Expenditures for Period
	San. Eng. Programs		Non-San. Eng. Programs		
	No.	Amount	No.	Amount	
1963	18	$ 680,000	8	$295,000	$1,100,000
1964	30	1,265,000	12	530,000	2,000,000
1965	32	1,275,000	12	467,000	2,000,000
1966	26	962,699	1	35,414	2,499,998
1967	29	1,195,378	1	35,367	2,908,842
1968	31	1,361,868	2	77,850	3,364,997

financial support in water quality engineering education, only 15.1 percent of the graduates of these programs accepted employment with the federal government following the 1966-67 and 1967-68 academic years.

Seven of the 45 programs reported having received PHS Solid Wastes Training Grants totaling $310, 145. Assuming that all 24 students receiving PHS training grants enrolled in solid waste programs are at these seven institutions, the cost to educate one student would be $12, 900 per year. These costs will surely be reduced as the programs reach maturity and probably will approach the level reported above for water quality programs.

SUMMARY AND CONCLUSIONS

In any critical analysis of the academic sector of a profession it is normally expected that deficiencies will be revealed and corrective recommendations made. However, in a field as diverse as sanitary engineering and with such divergent views as to what the field actually is and what it should be, the committee is hesitant to indulge in specific recommendations without the benefit of counsel from a wide cross-section of their colleagues in the teaching profession. Thus, the conclusions will be restricted to those bearing closely on the reported information, and recommendations can be obtained from the Report on the Second National Conference on Environmental and Sanitary Engineering Graduate Education held at Northwestern University, Evanston, Illinois, in August 1967.

1. The three principal designations describing the programs reported in the Register are sanitary engineering, water resources engineering, and environmental engineering. From 1965 to 1969, the number of schools using the "sanitary engineering" title remained relatively constant while the programs including "environmental" titles almost doubled. This increase in "environmental" designations was probably heavily influenced by the change in 1966 of ASEIB to EEIB. It is believed that to a limited degree these designations reflect the philosophies of the program faculties and the scopes of their offerings. Sanitary engineering still has the principal connotation of water quality; water resources implies a broader concern for water; environmental implies the full gamut of environmental factors especially related to health, principally air and water, but in some cases solid wastes, industrial hygiene, radiological health, and the other elements of the profession as defined in the N. C. R. Reports.

2. The distribution of faculty research and professional activity, as determined from their publications as reported in the Register questionnaire, clearly indicates the preponderance of interest in water science and engineering related to water quality. Only 8 programs reported degrees awarded in air resources in 1965 and 1968, and 11 schools reported enrollment in air resources programs in 1969. This suggests that the number of graduates in these areas should be expected to increase slightly in the years ahead. Similarly, only 5 in 1965 and 8 in 1967 and 1968 of the respondent programs reported awarding degrees in the radiological health category, while on July 1, 1965, 25 schools held active Radiological

Health training grants, again evidence of either unreported graduates, possibly because radiological training was not associated with the respondent programs in many of these schools, or because the programs are yet to reach maturity. It is also quite likely that many of the radiological health programs are not locally considered a part of the sanitary engineering programs. Only 6 schools reported enrollment in radiation and hazard control in 1969.

3. The growth in the overall sanitary engineering academic effort showed a marked increase in 1959-1960 as evidence by the sharp increase in the rate of production of degrees and this rate of degree production has continued to increase, especially those related to water quality. This change is reflected in corresponding increases in faculty strength and federal support. Nearly 60 percent of the students are receiving support in the form of traineeships or research employment by their institutions and a majority of the funds involved are of federal origin, this being slightly less than twice that for graduate engineering as a whole. Continued growth in the immediate future would appear to be dependent upon continued federal support. The many new opportunities for challenging employment in government and industry should provide a firm foundation for support of the programs in the future. However, in the past two years only 15.1 percent of the graduates have accepted initial employment with the federal government, which probably reflects the budget reductions recently imposed by the new administration. Unfortunately, it was not possible to assess the production of water chemists and biologists as these were reported separately by only one school and there was little evidence that many schools had developed specific academic programs in these areas.

4. Although an analysis of the Register permits the establishment of the present size and general scope of the sanitary engineering graduate programs, it does not provide adequate data as to their quality. Perhaps this is something that can never be ascertained by a questionnaire. Quality is most dependent on the excellence of the individual faculty members, especially as professionals and teachers, and not on their numbers or the monies and space they have at their disposal. On the other hand, it requires resources to attract outstanding young faculty and to support graduate students. The Register does not provide adequate information on the extra-program resources of the institution and their availability to advanced

students and faculty within the sanitary engineering program. Future editors of the Register should attempt to find some means of indicating program quality or strength and related resources of the institution within the limitations of their budgets and space available in the Register. These editors should, of course, not attempt to judge the quality of the programs but let the data speak for themselves as an aid to students searching for a school to best fit their graduate education desires. There remains the inherent difficulty of soliciting questionnaire responses that give truly representative information.

5. The 1969 Register displays actual graduate course programs which provide assistance to the prospective graduate student and also permit some general evaluation as to the overall strength and rigor of the programs. Are we making better engineers, chemists, biologists, etc., out of our graduate students or are we tending more and more toward the production of generalists who have no particular strengths? The graduate program for the engineer, as an example, should, in the opinion of the committee, relate his role to the overall effort but not at the expense of vigor in his professional engineering education. An attempt was made to estimate the balance of various programs; however, it would be most desirable to determine accurately if the graduate programs are achieving a balance between graduate preparation for professional practice versus preparation for teaching and research.

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