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NOTICE TO MEMBERS AND SUBSCRIBERS

Beginning with the current issue, the *Journal* will be published semiannually. The first issue in each year will be made as soon as possible after the annual meeting of the BSCE Section in April, the second about October.

The Publications Committee will make every effort to attract and publish interesting papers by members and others on subjects related to the fields of the Section's Technical Groups, the Civil Engineering profession and public needs which can be served by the professions. Each issue should reflect the really worthwhile presentations and discussions that go on in the many meetings of Technical Groups and Committees held each year.

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JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS SECTION

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VOLUME 68 • NUMBER 1 • SPRING 1982

STANLEY C. ROSSIER
President, Boston Society of Civil Engineers Section, ASCE
1982-1983

New President's Message

The challenge of the 1980's sweeps rapidly upon us as current events sharpen our concerns about the very future of our world, our nation, and our community. While human events rush onward, our sense of individual *autonomy* shrinks, our unique *body of knowledge* is seldom adequate, our personal *code of ethics* becomes questioned by others; our *community spirit* is sometimes lacking; and our *altruism* is all too often lost. Interestingly enough, these five items: autonomy, a unique body of knowledge, a code of ethics, a strong sense of community spirit, and altruism are the key attributes used by sociologists to identify a profession in our society and to learn its vitality.

As members of the Boston Society of Civil Engineers Section of ASCE, we enter our society's 135th year with a need to focus upon the development of our profession. One year ago David McCullough, author of "The Great Bridge" and "Path Between The Seas" caught our attention with his strong tribute to our profession and his great insight into the nature of human strengths which motivated a number of civil engineering pioneers. You may recall his story of a biology professor who assigned his freshman class the task of truly understanding and appreciating marine life by examining a dead fish before them on a laboratory bench. As the examination process got under way and questions arose, the professor answered each question with the summons: "Look at your fish!" After weeks of repeated and careful examination, a real understanding of the fish and his environment developed through the power of their own observation and careful interchange with fellow students concerning each person's observations.

In the coming year I invite each of you to examine carefully the development of our profession and the role of our Boston Society of Civil Engineers Section in that development. Let me hasten to assure you that I do not believe our profession is a dead fish! Civil Engineering is a growing profession well worth our full attention and greater nourishment. Let us undertake this evaluation to gain new insight and understanding concerning its state of development, not for the sake of self-study, but to form a stronger basis for future contributions by ourselves to the civil engineering profession and to the public we serve.

Autonomy, a unique body of knowledge, a code of ethics, a spirit of community, and altruism — each of these five attributes is vital if we are to maintain civil engineering as a true profession. To develop a strong sense of *autonomy,* we must take measure of our standards for entry, be certain they are briefly and clearly stated, and ask if they are truly appropriate. Autonomy also depends upon control of our own destiny. Our profession cannot be prepared to meet the challenge of consumer sponsored legislation concerning licensure and continuing education until we have developed our own position.

A *unique body of knowledge* has served us well; however, it is not a static entity. We must work to expand that knowledge through meaningful research funded by those we serve. We must continue to provide opportunities for individual members to advance their own knowledge through continued education and exposure to new concepts. Our publications should report not only technical information and historic contributions, but also serve as a forum to stimulate new concepts and ideas to serve professional development and public needs.

Our *code of ethics* need not become a printed paper in a drawer or file, but can be a living understanding concerning the motive of our relationships with peers and public. Serious issues lie before us. Since the Supreme Court has affirmed the Federal Trade Commission's authority to regulate competitive practices of professional groups, how are we to decide what constitutes "appropriate member advertising?" Now that salaries for college graduates rival those of college professors and persons with several years' experience, have we lost all perspective concerning the realistic monetary value of an individual's services? Other public service professions, involved in health care, are torn apart and weakened by a lack of perspective on this very issue!

We must strengthen the *sense of community,* or group solidarity, among civil engineers and other professional engineering societies without losing our unique self-identity. Further development of "The Engineering Center" within our community of engineering professionals can be one means to further this objective. The establishment of added technical groups and professional committees within our BSCE Section will broaden opportunity for individual involvement and thus expand our sense of community.

We can increase *altruism,* our spirit of service, through wider recognition that we are a "people serving profession." However, others will only perceive this spirit after each of us adopts service to the public as a personal goal and we all tailor our behavior accordingly.

I will expand upon some of these concepts for our Section in coming issues of the Newsletter. I ask each of you to share your own ideas and suggestions for making the BSCE Section an action-oriented professional organization that motivates civil engineers to further develop our profession and to better serve the public. Your own initiative and active participation are vital if we are to develop a more dynamic and enduring future.

Stanley C. Rossier
President 1981-1982

A YEAR IN REVIEW

***Presidential Address of Edward B. Kinner*[1]**

Introduction

This year concludes the 134th year of our Society's activities, and the 8th since the merger of the Boston Society of Civil Engineers with the American Society of Civil Engineers. In this, my final address to the Society as President, I will comment on the goals which I had set for the year and discuss some of the Society's activities in the last 12 months. I will close with some general recommendations and comments for the future.

Review of Year's Goals

Society Interaction

One of the goals that I set related to interaction within the Society of the members on both a social and technical basis. This goal was based on receipt of numerous comments from members indicating that Society activities were too narrowly focused. That is, more non-technical activities were desired and individual technical meetings were requested to be structured so as to attract persons from several technical disciplines.

Accordingly, the luncheon program was continued. This met with mixed success. The luncheons which had greatest success were one which offered a presentation by Massport on forthcoming projects and one describing a tunneling project in Baltimore Harbor. Each of these was attended by over 100 persons. Only poor to modest attendance was experienced at two other luncheons and another was cancelled because of a dismal number of reservations. My conclusion is that most individuals will not attend an activity solely to support the Society and to mingle with others. A program must be provided which is perceived by a broad sector of the membership to be of positive benefit, either technically, socially, or both. This observation is perhaps obvious but must be kept clearly in mind, regardless of the function. My recommendation for the luncheon program is that it be continued, but the number of meetings be limited to about three each season. This will permit the committee to emphasize topics and speakers of particularly broad appeal.

[1]Presented at Part I of the Annual Meeting of the Boston Society of Civil Engineers Section, ASCE, April 26, 1982.

The Clambake was attended by about 300 people on 12 August and was a great success. This event has had excellent attendance for the last few years and I strongly recommend its continuance. My one suggestion is that it be held on or before 5 August because of the earlier sunsets in later summer.

The annual dance was held, after a one year lapse, in an effort to rekindle enthusiasm which had been waning in recent years. I believe that everyone present had an excellent time, but the turnout was small even though the organizing committee did an outstanding job in publicity and arrangements. The dance was held on a Saturday evening and not in conjunction with a dinner. Some persons have stated that they would not come unless there were a dinner. Others have said they would not come because of the expense if there were a dinner. My conclusion is that in the 1980's there are so many pressures on members' time that a dance is not on most individuals' priority lists. I therefore recommend this function be dropped until such time that there is an unmistakeable groundswell of interest for it.

A large number of technical meetings were cosponsored by two or more technical groups or committees. From the standpoint of both society interaction and technical content, I believe these were successful and I suggest this manner of scheduling activities be continued.

The one goal concerning Society interaction which was not fully realized relates to joint meetings of the Society with Student Chapters. A Caucus was held wherein Student Chapter advisors and officers met with the BSCES Board and other members. This was a great success. Additionally, the Student Night at Southeastern Massachusetts University was well attended by both practicing engineers and students. However, there were only one or two technical meetings of the Section which were joint meetings with one or more student chapters. For this, I must accept responsibility and offer the recommendation that there be more joint meetings with student chapters in the future. On the positive side, the Student Affairs Committee sponsored a "free-lunch" program on a trial basis, allowing students to attend meal functions at no cost. This met with limited success while in operation, but the program had to be terminated due to budget limitations.

Section Finances

Several goals were established relative to the finances of the Section. Before discussing them specifically I will provide an overview of our financial accounting system as it stands today.

- Current Fund

The operating fund of the Section is the Current Fund. The annual budget by which the Section operates this year totals approximately $95,000. The budget is divided into the following eight broad categories.

1. Income accounts: dues from members, interest and dividends, transfer of income from the Permanent Fund, transfers to the operating budget from technical group lecture series reserve accounts, allotment payments from ASCE national, and contributions.

2. Office costs: BSCE's share of payroll and benefits for the Executive Director and Secretary; business taxes, rent and utilities; office supplies and equipment; the monthly newsletter; telephone and other associated items.

3. BSCES Journal: printing and mailing of the Journal, advertising revenue, non-subscription sales and reprints.

4. General society business: financial support to the Western Massachusetts Branch, monthly dues to the Design Professionals Government Affairs Council, general awards and special dues and conference expenses.

5. Meetings and Social Affairs: The BSCES Annual Meeting Dance, Clambake and luncheon program.

6. Technical Groups: Activities of the seven technical groups.

7. Student Affairs: The Summer Institute at Northeastern University for minority high school students, Student Night, the student leadership session and other items.

8. Committee Operations: Activities of standing and special committess such as History & Heritage, Action Program-Professional Practice, Employment Conditions, Public Relations and Energy.

The greatest net cost to the Section comes from categories 2 and 3, BSCES office costs and the Journal, respectively. Details of income and revenue for specific items are available in the Treasurer's report for reference.

- Invested Funds

  In addition to the Current Fund for regular operations, the Section has what are called Invested and Non-Invested Funds. The Invested Funds are comprised of the Permanent Fund and special funds such as the Freeman, Camp and Convention Funds which were established by gifts, bequests or by the Board of Government. The Annual Report of the Board of Government and the Treasurer's report contain further details on these funds. Basically with few exceptions, use of principal and income from these Invested Funds is restricted by the terms of the initiating gift, bequest or Board action. Where appropriate, income from selected Funds is transferred to the operating budget to help offset expenses. The present market value of the Invested Funds is approximately $296,000.

- Non-Invested Funds

  The Non-Invested Funds are other monies under the control of the Section which are not specifically within the Current Fund or in special investments as mentioned above. For example, monies earmarked for publication of Boston area boring data in the Journal are included in the Non-Invested Funds. The Non-Invested Funds are controlled by the Treasurer and currently total about $30,000. Further details can be found in the annual reports previously mentioned.

Having provided this lengthy introduction, I will now review the principal aspects of what was accomplished this year relative to finances.

The first goal related to a restructuring of our accounting system. A professional accountant was retained to assist in this effort. New cash received and cash paid books were established and ledgers developed for the individual Section funds. The budget for the Current Fund was reordered and consolidated. The very important recognition was also made that Invested Funds should be separated from the Current Fund. This eliminated considerable confusion which had existed in some minds relative to content of the annual budget. A review was also made of monies allocated to the Invested and Non-Invested Funds, and payments due to these funds for loans made to the Current Fund were paid back. The policy was also established to require the Treasurer to submit the annual financial report as soon as possible after the close of the fiscal year on 30 September, as opposed to the time of the Annual Meeting in April as previously. In addition, the Treasurer is now required to submit an interim financial report for the current fiscal year through 31 March at the Annual Meeting in April. Lastly, new methods for approval of disbursements were established.

Another financial goal related to the budgeting process of the Section. Costs for the current fiscal year were trimmed or held constant where possible. A Committee on Financial Responsibilities, chaired by Past President Howard Simpson, was appointed to examine a number of Section financial matters. One of the important recommendations coming from the Committee resulted in the establishment of a Budget Committee, composed of the Senior Vice President as Chairperson and the President, Treasurer, Secretary and Executive Director. Formerly all budgeting was the responsibility of the Treasurer. The Committee can now better represent the views of the Board of Government in budget matters, and less of a burden is imposed on the Treasurer. At my request, an initial budget meeting for the forthcoming fiscal year has already been held.

The next financial goal related to dues. In my "New President's Message" a year ago, I indicated that a review of dues levels would be undertaken although I hoped an increase would not be necessary. As the restructuring of our accounting system progressed, it became apparent that a dues adjustment was necessary. This was recommended to the membership by the Board and subsequently approved.

As I had also planned, a review was made of the desirability of having the ASCE national office in New York collect our Section dues as opposed to the independent solicitation of Section dues which we currently do locally. After a brief assessment, I concluded that we should not proceed further with such an effort at this time. If adopted, the process would still have required considerable follow-up by our office staff, and our close to 300 BSCES members who are not ASCE members would have required separate billing anyway. Lastly, my personal opinion is that there is a responsiveness to local dues collection which might be lost in a more remote solicitation by the national headquarters. Dues collection by the New York office, however, should be maintained as a possibility and evaluated again in the future.

The last principal goal for the year related to the management of our investments, the Invested Funds. It was intended to review the return on our investments which had been achieved by the current Custodian, Boston Safe Deposit and Trust Company, and to determine the direction that our investment policies and management should take. This goal was established largely as a result of concern raised by the Freeman Fund Committee relative to past performance.

By the end of the year, the Investment Committee had determined that inadequate performance had in fact been realized. The Committee recommended to the Board of Government that our monies be withdrawn from the Boston Safe Deposit and Trust company and reinvested in three growth-income mutual funds.

I am pleased to report that the Board acknowledged the inadequacy of past returns by voting to terminate our agreement and to withdraw our funds for reinvestment elsewhere. The actual withdrawal awaits final Board acceptance of the Investment Committee's recommendations for the specific investment vehicles to be used.

The Board's action concerning our custodial agreement and past performance marks a significant accomplishment. It is my hope that agreement on specific future investment procedures can be reached with relatively little additional effort.

Before leaving the topic of Section finances, I wish to make two points. The first is that diligent efforts by the Board will be required for the forseeable future to maintain an acceptable balance of income and expense while continuing to provide the desired program. Secondly, I wish to acknowledge two individuals who have made outstanding contributions this year. They are Treasurer Richard Murdock and Secretary Rubin Zallen. Without their tremendous efforts much of what has been accomplished would have been left undone. On behalf of the entire Board of Government, I offer our special thanks to them.

BSCES Journal

The Journal is the next area for which a goal was established at the beginning of my term. A year ago the Publications Committee report on the Journal resulted in the decision to reprint papers of significant historical interest and to emphasize case study papers and those of practical interest. Additionally, each of the technical groups committed itself to providing at least one good paper yearly. My goal was to see these plans implemented.

An outstanding Journal issue was published in connection with the dedication of the Charles River Basin as a National Historic Civil Engineering Landmark. This was due to the fine efforts of the Freeman Fund Committee. The Journal issue within which this message is to be published will also contain a very good set of papers.

I have great concern for the future, however. To my knowledge, the pipeline is now almost dry. It is the technical groups to whom I appeal. The Journal cannot survive without papers and it is your membership and programs which will produce them. I ask each Group to vigorously pursue the commitment which it has previously made.

Membership

The last goal which I set related to vigorous pursuit of new members. The year 1982 was declared a Membership Year by ASCE National. We have been doing our best to support our membership needs locally as well as the national effort. I devoted one of my monthly newsletter messages to membership and in that newsletter, contact cards to fill out and return on prospective members were mailed to everyone. In addition, these contact cards have been distributed at technical group meetings and I "talked up" membership at numerous functions. The Membership Committee has been doing a good job of following up on names submitted on the contact cards. In addition the Committee has been working locally through individuals in firms and organizations.

The Board of Government in March also approved the concept of a local Student Member grade, consistent with establishment of such a grade by the national organization. A formal change to our Constitution is in process to permit this addition and I hope that within a year or so, we will have a Student Grade locally. This should facilitate continued infusion of young engineers.

Even with all these efforts, the numbers in this year's Report of the Board of Government are not good, in that we had a greater loss than addition of members. This is partially due to a long-standing administrative practive in the Section office which only recently became known to me, relative to dropping members because of non-payment of dues. I strongly recommend that from now on no member be dropped for non-payment of dues until the Membership Committee has followed up with the delinquent persons individually.

Review of Other Events

This completes my discussion of the principal goals which were set for the year. In the course of this presentation I have mentioned many of the Section activities which have occurred. There are some other notable events which I believe are worthy of a consolidated listing for the permanent record. I do this at some risk of one or more serious deletions for which I apologize if they occur.

1. Over 25 technical group meetings were held as a continuation of our excellent technical program.

2. Technical advisory committees were established by the Board in the areas of seismic design, foundations and loads to continue the very important work that had been underway in these areas prior to the demise of the Massachusetts State Building Code Commission.

3. A Hazardous Waste Committee was established and the Section has offered its services to the Commonwealth's Hazardous Waste Facility Site Safety Council.

4. A Waterway, Port, Coastal and Ocean Technical Committee was formed as a hopeful prelude to its becoming a Technical Group in about a year.

5. The Structural Group held a lecture series on "Design of Building Cladding" and the Transportation Group sponsored a seminar series on "Managing Stress, A Positive Approach for Engineering Executives." Several lecture series are also now in the planning stages.

6. ASCE President James Sims was in Boston last November for the dedication of the Charles River Basin as a National Historic Civil Engineering Landmark. The Borden Base Line in Western Massachusetts has been designated by ASCE for similar recognition and will be dedicated in the future.

7. Over $1100 was received in voluntary contributions from the membership to further support our programs.

8. The Action Program-Professional Practice Committee assisted in nomination of an engineer to fill a position on the Commonwealth's Designer Selection Board. In addition the Committee submitted nominations for a position on the Boston Zoning Commission and one on the Zoning Board of Appeals.

9. The Student Affairs Committee reorganized and revitalized the Student Contact organization for liaison between the Section and the student chapters. The Committee also developed a first-of-its-kind Student Contact Handbook.

10. Three past Presidents of the Society died during the year. They were:

Ralph W. Horne	BSCE President 1932-1933
Arthur Casagrande	BSCE President 1957-1958
Bertram Berger	BSCE Section President 1976-1977

Mr. Horne and Dr. Casagrande had long and very productive careers and made contributions to the profession which will be remembered by many in future years. Mr. Berger, likewise was an example for us of an energetic, forward looking and tireless professional. His sudden death in the prime years of his career is a great loss.

Recommendations for the Future

In addition to comments made previously I have some further recommendations for the future.

1. The environment within which we as professionals and the Section must operate is complex and becoming more so. Our liaison relative to legislation in Massachusetts is through the Design Professionals Government Affairs Council. I urge that the Section work more closely with the Council and its Staff Director in the coming year to ensure that the Council maintains required contact with events on Beacon Hill and provides us with timely input and guidance.

2. Our Energy Committee requires more broad based support from the membership. This is a multi-discipline field that should be of interest to us all. I urge that input for continued and broad based programs be provided to the Committee.

3. In the area of finances I once again underscore the need for continued diligence relative to budgeting and cost efficiency in our operations, while maintaining our excellent programs.

4. Membership is an area which should receive continued attention from the highest levels in the Section.

5. In recent months the concept has evolved for establishment of an expanded Engineering Center. This Center would serve a greater number and perhaps a different mix of societies than are presently at 80 Boylston Street. It is one of incoming President Rossier's goals to evaluate this concept further and I strongly support his plan.

Closure

In closing it is my hope that the review of this past year's goals and other events has served to underscore the truly excellent organization which is the Boston Society. The strength of our organization is not due to one person or one Board of Government. Rather it is due to sustained support from an energetic and concerned membership. We can be proud of what we all have in our Society. The Society is much like good marriage, most of the time strong, at other times less so, but always requiring nurturing for continued richness. We must be particularly mindful to guide and support our organization and profession, for only we can sustain them. This is particularly important in these times of economic uncertainty, litigation, governmental regulation and public cynicism.

Lastly I wish to express my appreciation for having had the honor to serve as the Boston Society President. I thank you all for your support. This year has been one of challenge and great interest. On behalf of the membership, I wish incoming President Rossier and the new Board of Government a successful year.

INTRODUCTION OF FREEMAN MEMORIAL LECTURE

***By the John R. Freeman Fund Committee of the Boston Society of Civil Engineers Section of ASCE*[1]**

This Eleventh Freeman Memorial Lecture is of special note because the lecturer, Gerhard Jirka, was awarded the Freeman Hydraulics Prize for the paper he is delivering. Professor Jirka is the second recipient of that prize, which was inaugurated when Hunter Rouse received it in 1975, for his book Hydraulics in the United States, 1776 - 1976.[2/]

Both the Memorial Lectures and the Hydraulics Prizes are spiritual and material offshoots of the Freeman legacy. During his exemplary career - documented in Rouse's book, cited above and elsewhere - John Ripley Freeman endowed traveling scholarships with ASCE, BSCE and ASME. The firm foundation which supports hydraulic engineering in the United States today is attributable, in large part, to the work of men who benefited from these scholarships. And it is the income from Freeman's gift to BSCE which supports these lectures and awards. The introduction of the Tenth Memorial Lecture, which was published in 1979 in both the BSCES Journal and the Proceedings of ASCE, makes reference to previous Memorial Lectures and Freeman's unique career.

1/ Lee Marc G. Wolman, F. ASCE, David R. Campbell, Harry L. Kinsel, F. ASCE, Lawrence C. Neale, F. ASCE, and Donald R. F. Harleman, M. ASCE.

2/ Institute of Hydraulic Research, The University of Iowa, Iowa City, 1976; Journal of the BSCE Section ASCE, Vol. 63, 1976.

Gerhard H. Jirka, the Eleventh Freeman Memorial Lecturer, is an Associate Professor in the School of Civil and Environmental Engineering at Cornell University. He has been at Cornell since 1977, following eight years at M.I.T., where he earned M.S. and Ph.D. degrees and served on the research staff of the Ralph M. Parsons Laboratory of the Civil Engineering Department. A native of Austria, he received the Dipl. Ing. (with honors) from the Hochschule für Bodenkultur in Vienna in May 1969. His Fulbright Grant is a strong reminder of the Freeman Grants, whose recipients worked and learned in the pioneering model laboratories in Germany and later became major contributors to the development of hydraulic engineering in the United States.

Jirka's major professional interests today are in the fields of fluid mechanics and energy. In the former, he is pursuing investigations in stratified flow, turbulence, experimental techniques and transport phenomena in water quality; and in the latter, he is working on the fluid mechanical aspects of alternative energy systems, ocean thermal energy conversion, the environmental effects of energy facilities, and heat disposal - the subject of his Freeman Lecture.

He has been a major and prolific contributor to the technical literature in his fields. His Papers, mostly co-authored, cover both theoretical and physical model studies. He has authored or co-authored ten papers and four discussions in ASCE Journals and presently serves on four committees of the Society's Hydraulics Division.

MULTIPORT DIFFUSERS FOR HEAT DISPOSAL - A SUMMARY[1]

By Gerhard H. Jirka[2]

Abstract

This paper reviews the fluid mechanical characteristics - as derived from theoretical and experimental studies during the past dozen years - of submerged multiport diffusers used for heat disposal from thermal power plants into the water environment. Foremost among these characteristics is the near field instability produced by such thermal diffusers in typical receiving water conditions. Rather than forming a distinct buoyant plume as is the case for the traditional sewage diffuser, the high discharge momentum of thermal diffusers leads to a flow breakdown with local recirculation zones and full vertical mixing. Stability diagrams for both stagnant and flowing ambient conditions are presented. The flow and temperature fields at larger distances, in the intermediate field, are, in turn, critically dependent upon how the discharge momentum is introduced into the ambient fluid layer. Out of a spectrum of possible diffuser designs three major types have evolved. The unidirectional and staged diffusers are designs which result in concentrated vertically mixed plume motions. The alternating diffuser with appropriate nozzle control generates a stratified flow field outside the unstable near field. Predictive techniques for these basic types are summarized. A typical case comparison illustrates their differences in engineering design and environmental impact.

Preamble

Inasmuch as the elapsed time interval may permit us to gain a proper historical perspective, we have begun to label the 1970's the "environmental decade". Indeed, this characterization seems entirely justified. A series of environmental disasters in the late sixties - Santa Barbara oil spill, Cuyahoga River burning, Lake Erie fish kills - spurred the environmental

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[1]The Eleventh John R. Freeman Memorial Lecture. Presented at a joint meeting of the Hydraulics Group of the Boston Society of Civil Engineers Section and the M.I.T. Student Chapter of the American Society of Civil Engineers, at M.I.T., April 21, 1982.

[2]Associate Professor, School of Civil and Environmental Engineering, Cornell University, Ithaca, New York.

movement, and led to a surge in public awareness and, ultimately, resulted in sweeping legislations with the intent of controlling the human impact on the environment. Much of this process, though long overdue, was impulsive, hasty and narrowly focused. Frequently, it lacked a scientific base, a tradeoff between one environmental impact versus another and due consideration for conflicting societal objectives, such as economic costs. The concurrent energy crisis exacerbated the latter conflict. Consequently, considerable "re-interpretation" and "adjustment" of earlier legislation took place in the latter part of the decade. Undoubtedly, this development will continue. A sound and balanced environmental policy which is grounded in a mature public perception of all inherent conflicts and trade-offs is the hope for the future.

The research and development of the submerged multiport diffuser technology for waste heat management of steam-electric power stations is closely linked to the environmental history of the 1970's. With the advent of large capacity central power stations it became evident that the traditional surface discharge scheme which used to be the dominant once-through heat disposal technique was unsatisfactory in most receiving water environments: it seemed to result in large regions of raised surface temperatures and often with significant shoreline impact. Thus, in the late sixties and early seventies the multiport diffuser was heralded by the engineering community as the solution to the thermal pollution issue. However, this early impetus for technology development and implementation was soon waning when the following obstacles emerged. First, several state environmental agencies issued overly restrictive temperature standards and mixing zone requirements; at least, they appear so in retrospect in the light of accumulated experience and scientific evidence. This led to exceedingly costly diffuser designs and thus diminished the main economic advantage of once-through heat disposal techniques over closed-cycle cooling towers.

Second, design engineers and regulatory reviewers were frustrated by the absence of simple predictive mathematical techniques for diffuser design and/or design verification. Early attempts to draw on the seemingly related problem of submerged diffusers for sewage disposal proved a dismal failure when compared to the few available experiments. Thus, design had to proceed with time-consuming and costly hydraulic model studies. Third, the Federal Water Pollution Control Act Amendments of 1972 defined thermal discharges as a pollutant. Therefore, the Amendments' goal of zero pollutant discharge by 1985 appeared to suggest the elimination of once-through heat disposal schemes. Subsequent studies by the U.S. Environmental Protection Agency proposed the mechanical draft evaporative cooling tower as the "best available" control technology. But, just as the extreme philosophy of "zero pollutant discharge" into water has come under increasing attack for its lack of a balanced consideration of air, land, energy and water resources and of economic consequences, there has been an increasing use of several important exemptions of the 1972 Amendments. In essence, these exemptions allow the utilization of once-through schemes if systematic ecological studies of the receiving water demonstrate that the discharge assures "the protection and propagation of a balanced, indigeneous community of fish, shellfish and wildlife". This trend toward a site specific assessment methodology, rather than a strict advocacy of one technology versus another one, is indeed a healthy one. Thus, recent years have seen a continued and renewed interest in multiport diffusers. A recent study (36) on the ability of once-through systems to comply with typical thermal standards - note, that this compliance can, of course, only be seen as a surrogate to a systematic assessment of the site-specific ecological impact - concluded: "Submerged multiport diffusers were found to provide the greatest likelihood of meeting thermal standards in all receiving environments" (i.e. rivers, lakes, estuaries and coastal waters).

This writer anticipates that, in the future, submerged multiport diffusers will be the preferred heat disposal alternative for central power stations, whenever a sufficiently large water body is available near the plant site. Thus, it is the purpose of this paper to summarize recent analytical and experimental results on thermal diffuser mechanics together with some operational experience on completed installations. It is shown that there exist several types of thermal diffusers with rather divergent characteristics. An understanding of these types is a prerequisite for the design engineer to use thermal diffusers as a truly flexible tool for environmental management.

I. Introduction and Definitions

A multiport diffuser is defined as a linear structure consisting of many closely spaced ports or nozzles which inject a series of turbulent jets at high velocity into the receiving water. These ports may be attached as risers to an underground pipe or, simply, may be openings in a pipe lying on the bottom. This diffuser pipe, usually of varying diameter to insure the desired flow distribution through the individual ports, is connected by means of a feeder pipeline to the onshore power plant.

The interplay of diffuser location, design details and ambient conditions, as indicated in Fig. 1, determines the resulting temperature and velocity fields in the receiving water. An adequate prediction of these fields is a basic requisite for further environmental impact analysis of a proposed installation. Most usefully, such predictions are carried out in a "zonal approach", that is, subdividing the expected flow field into zones of unique characteristics. Different such subdivisions made on an ad-hoc basis may be found in the literature. For the present purpose, we will use subdivision into three zones: the near field, usually a highly three-dimensional zone, in which the individual jets interact, effectively entrain, and diffuse their momentum into, the surrounding fluid; the intermediate field in which large scale motions and circulations - often in form of a distinct "diffuser plume" - are set up with additional, though less vigorous, mixing and buoyant spreading; and the far field in which advection and turbulent diffusion by ambient currents dominate. In essence, the far field constitutes a passive dispersal process. Its analysis which follows the traditional pattern of Eulerian or Lagrangian-type transport models will not be considered herein. Rather, attention is restricted to the active dispersal processes which make up the near and intermediate field zones.

That the active dispersal zones produced by modern large heat diffusers can extend over considerable distances and can cause a significant influence on the ambient hydrologic structure is shown in the following illustrative example. The example also serves to document some of the fundamental fluid mechanical differences between "thermal diffusers" and "sewage diffusers". We consider a coastal city with a population of one million. Given U.S. national averages, the city's installed electric capacity is of the order of 2000 MW and its flowrate for combined sewage and stormwater runoff is of the order of 200 million gallons per day. Assuming a central station nuclear power plant with once-through cooling and a single regional sewage treatment facility, Table 1 gives the respective discharge flow rates, Q_o. Several installed or planned outfalls of either category have discharges of this magnitude and larger. We note that the cooling water flowrate exceeds the sewage flow by a factor of 10. Referring to Fig. 1, it can be seen that multiport diffusers exhibit a tantalizing amount of detail, e.g. discharge velocity U_o, port spacing ℓ, vertical port angle θ_o, horizontal port orientation β, all of which may be variable along the diffuser axis. For the moment, we neglect much of this detail and concentrate on the two flow parameters which we expect to have major influence on the global dynamic characteristics of the diffuser flow field. Those are the total buoyancy flux, P_o, and the total momentum flux, M_o, both expressed in kinematic units, $P_o = Q_o \frac{\Delta\rho_o}{\rho_a} g$ and $M_o = Q_o U_o$, where $\Delta\rho_o = \rho_a - \rho_o$, ρ_o = discharge density and ρ_a = ambient density. Because of a tenfold discrepancy in the relative density differences which is due to the fresh-salt water interaction in one case and the thermal expansion in the other, the buoyancy flux is in fact the same for both diffusers. It corresponds roughly to the buoyant weight of a volume of 0.2 m^3 (7 ft^3) released per second. On the other hand, given a typical discharge velocity of 5 m/s (9.8 ft/s) the momentum flux for the thermal diffuser is ten times larger. The further implications of these flux parameters must be considered in the context of diffuser site selection. Sewage diffusers require deep sites, H of the order of 50 m (163 ft), because health regulations impose rather high near-field dilutions (order of 100 and more). The required near-field dilution for thermal diffusers is much lower, 5 to 10, so that the diffuser can be located in much shallower water, H of the order of 10 m (33 ft). For a typical diffuser length, L_D = 500 m (1640 ft) the distributed momentum flux which impacts the available water column, L_D H, hence $M_o/(L_D H)$, is fifty times larger for the thermal diffuser. Hence, much stronger accelerations take place within the receiving water. Although with the present global analysis we cannot predict the induced velocities - this will depend, as is shown later on, on some of the details presently omitted, e.g. port orientation - we can expect the induced velocities to be of order $[M_o/(L_D H)]^{1/2}$. Using an ambient velocity of 0.3 m/s(1 ft/s) as a convenient reference velocity for offshore currents of tidal, wind driven or inertial origin, we find that the thermal diffuser induces velocities of equal magnitude while the velocity field induced by the sewage diffuser is probably not detectable in the signal noise of the ambient current.

Hence, the following conclusions can be drawn on the basis of these rather general considerations: 1) The near field mixing of a thermal diffuser is strongly influenced by its momentum flux. For a sewage diffuser, however, the role of the momentum flux is minor and its mixing is governed by its buoyancy flux as is known from previous work (e.g., 26). 2) The intermediate field of the thermal diffuser is characterized by large induced velocities which can be expected to persist over considerable distances and to cause a modification of the ambient coastal circulation system. The intermediate field dynamics are largely non-existent in sewage diffuser discharges - except for some buoyant collapse motions - and its overall flow field is given by a direct transition from near field (buoyant plume) processes to far field processes. This radical departure of thermal diffuser analysis from established procedures for sewage diffusers is further highlighted in the remainder of this paper. We review studies of the near field behavior (Section 2) and of the induced circulation patterns for different diffuser types (Sections 3 to 6) both of which are fundamental to the understanding of the active dispersal phases of a thermal diffuser. Finally, some design implications are discussed (Section 7) and the paper concludes with suggestions for future work.

2. Near Field Stability

It is intuitively obvious that, depending on the role of buoyancy, the injection of turbulent jets into an ambient unstratified fluid layer can generate radically different flow patterns in the immediate discharge vicinity, the near field. In the absence of buoyancy, on the one hand, we expect that the discharge will cause recirculating eddies within the limited layer as the jet is deflected by opposite fluid boundaries. Discharges with strong buoyancy, on the other hand, are expected to rise in form of a bouyant jet toward the fluid surface and to spread along the surface in form of a well defined layered flow. Hence, the object of the near-field stability analysis is to predict under what combinations of discharge and ambient characteristics the near field will be stable or unstable. A stable near field is defined as one in which a buoyant surface layer is formed which does not communicate with the initial buoyant jet zone, as illustrated in Fig. 2a. The near field is defined as unstable whenever the layered flow structure breaks down in the discharge vicinity, resulting in recirculating zones or mixing over the entire water depth, as shown in Fig. 2b.

Whilst the general flow field of a diffuser is always a highly three-dimensional one, we introduce for purposes of the stability analysis a two-dimensional channel model (see Fig. 3). This assumes that the flow field in the diffuser center portion is approximately two-dimensional. Furthermore, the details of the individual jets with initial diameter D and spacing ℓ are neglected by assuming an equivalent slot jet with slot width $B = (D^2\pi)/(4\ell)$ on the basis of equivalency of momentum flux per unit diffuser length. This equivalent slot concept has been shown to be sufficiently accurate representation of the mixing of merging individual jets (14,23,25) if attention lies in the region after merging. For the tangent, $k \approx 0.5$, of the total angle of spread of a round turbulent jet (41), the condition for merging would be $\ell/H < 0.5$ for the extreme case of a vertical discharge. However, the results derived in the following have been found reliable for even larger spacings.

The major dynamic elements in this two-dimensional framework which affect the near field stability of a discharge from slot width B and initial angle θ_o into a layer depth H are then the buoyancy flux per unit length, p_o =

$U_o B\, g'_o$, in which $g'_o = \frac{\Delta\rho_o}{\rho_a} g$, as a stabilizing element and the momentum flux per unit length, $m_o = U_o^2 B$, as a destabilizing element. Furthermore if an ambient crossflow exists in the direction of the channel then its momentum flux per unit length, $m_a = u_a^2 H$, also will play a destabilizing role. These two destabilizing elements are considered separately.

2.1 Stagnant Ambient:

The premise of the stability analysis is to define a mathematical model for the stable discharge configuration which includes the horizontal surface layer spreading after jet impingement. Then, decreasing the buoyancy flux in the model will eventually lead to an instability and breakdown of the layered structure. This condition, the stability criterion, is attained when the inertia forces overcome the stabilizing effect of buoyancy. Details of this analysis and its experimental verification have been given elsewhere (21, 23, and 24 for the special case of vertical discharge, $\theta_o = 90°$) and a summary only is given here.

Experimental data (e.g. Fig. 2b) and basic stratified flow theory suggest that under stable near field conditions the following structure exists in the two-dimensional channel configuration: (i) A buoyant jet region in which the discharge entrains ambient water while rising toward the surface. This region is analysed using Morton et. al's (35) entrainment concept with a variable entrainment coefficient which depends on the local densimetric Froude number of the jet and on the local jet angle. For the special case, $\theta_o = 90°$, this variable entrainment approach is shown to agree with the constant buoyant jet spreading analysis as proposed by Schmidt (43) and Abraham (1) which appears to be in closest agreement with available data. (ii) A surface impingement region provides a transition between the buoyant jet flow which has a strong vertical component and the horizontal spreading motion. A control volume analysis which includes continuity and momentum conservation and allows for internal energy dissipation in the abrupt change of flow direction gives the geometric and dynamic characteristics of the initial spreading layer. In particular, it is found that the layer (in both $\pm$ x directions) always spreads supercritically in the sense of an internal densimetric Froude number defined on basis of layer velocity, thickness and buoyancy. (iii) An internal hydraulic jump region links the supercritical counterflow system after impingement with the ensuing subcritical counterflow region. Thus a rapid change in flow state takes place which is analysed using the momentum conservation principle. These three regions together constitute the near-field zone while the gradually varying stratified counterflow is in fact an intermediate field process which connects the discharge to the surrounding large basin, i.e. the inert far-field.

The complete analysis of the three near field regions indicates that a transition to a stable intermediate field flow is possible only for sufficiently high discharge buoyancy. For smaller values of discharge buoyancy no conjugate solution can be found which would satisfy the momentum conservation equation governing the internal hydraulic jump. Consequently, a flow breakdown may be anticipated which leads to dissipation of the excess momentum in the form of a recirculating eddy zone.

The theoretical predictions of the stability criterion is given in Fig. 4 using the parameter space of a discharge slot densimetric Froude number $F_s = m_o^{3/4} p_o^{-1/2} B^{-3/4}$ and relative depth H/B with the discharge angle θ_o as the third variable. This stability diagram indicates a stable near field for low F_s and large H/B so that a stable discharge can be labeled synonymously as a "deep water" discharge. The parameter range of large F_s and low H/B, on the other hand, is unstable, i.e. a "shallow water" discharge. The symmetrical discharge condition, $\theta_o = 90°$, is more stable than asymmetric discharges,

$\theta_o < 90°$, which result in a net horizontal acceleration of the ambient flow. Experiments over a wide parameter range are in good agreement with the theoretical criteria (see Fig. 4).

For the asymptotic condition $H/B \rightarrow \infty$, the stability criterion is closely represented by a simple best-fit expression

$$\frac{H}{B} = 1.84\ F_s^{4/3}(1 + \cos^2 \theta_o)^2 \tag{1}$$

This is a good approximation for $H/B > 200$. This fact suggests to neglect the slot width as a significant parameter, $B \rightarrow 0$, by combining F_s and H/B into a new parameter $m_o/(p_o^{2/3}H) = F_s^{4/3}/(H/B)$. Using Eq. 1, the stability criterion for a line buoyant jet in confined depth is given by a convenient two parameter expression

$$\frac{m_o}{p_o^{2/3}\ H} = \frac{0.54}{(1 + \cos^2 \theta_o)^2} \tag{2}$$

It is interesting to apply this criterion to the earlier comparison between sewage and thermal diffusers given in Table 1. We find $m_o/(p_o^{2/3}\ H) =$ 0.08 and 3.84, respectively. Thus, typical sewage diffuser operate clearly in the stabledomain while thermal diffusers have an unstable near field. These points are also included in Fig. 5 as "S" and "T", respectively. Hence, simple buoyant jet analyses which in essence assume an infinite receiving water body suffice to calculate the mixing characteristics of sewage diffusers. Conversely, altogether different techniques must be employed in the design of thermal diffusers where a distinct jet zone does no longer exist due to the flow breakdown in the near field.

2.2 Ambient Crossflow:

The additional destabilizing effect of an ambient crossflow of velocity u_a which is superimposed on the diffuser operating in the two-dimensional channel conceptualization can be represented by another parameter $m_a/(p_o^{2/3}\ H)$. So far, a detailed analytical development of the stability criterion for this situation is wanting. A simple estimate for the momentumless discharge case, $m_o/(p_o^{2/3}\ H) \approx 0$, can be given using a result of stratified flow theory which indicates that layered flow is only possible if the densimetric Froude number $F_a = q_a/(g'\ H^3)^{1/2}$ is less than a limit value $F_a^* = 1$ where q_a is the net discharge and $g' = \frac{\Delta\rho}{\rho_a} g$ the buoyancy difference between the layers. Several experimental results (e.g. 15) indicate that, in practice this limit is even lower, $F_a^* = 0.6$ to 0.7, apparently because of the neglect of vertical accelerations in the theory. However, if the stable stratified discharge flow is experiencing this limiting breakdown condition leading to vertical mixing, then $g' = g_o'/S$ where S is the mixing ratio given by $S \approx q_a/q_o$, approximately. Appropriate substitution and use of $F^* = 0.65$ yields an estimate for the stability criterion

$$\frac{m_a}{p_o^{2/3}\ H} = (F_a^*)^{4/3} = 0.56 \tag{3}$$

Thus, comparing Eq. 3 with Eq. 2 it can be seen that the discharge momentum flux m_o plays a quantitatively similar destabiliizing role as the horizontal ambient momentum flux, m_a. On the other hand, Eq. 2 indicates that the tendency to instability is further increased if the discharge momentum also has a horizontal component, $m_o \cos\theta_o$. In situations involving both horizontal momentum flux elements, m_a and $m_o \cos\theta_o$, the separate destabilizing roles of the total horizontal momentum flux, $m_a + m_o \cos\theta_o$, and the total discharge momentum flux, m_o, - both scaled by the stabilizing factor $p_o^{2/3}H$ - can then be displayed in a general stability diagram as shown in Fig. 5. Furthermore, given the numerical constants of Eq.s 2 and 3 an approximate stability criterion for small slot width, $H/B \to \infty$, can be proposed as

$$\frac{m_o}{p_o^{2/3}H} + \frac{m_a + m_o \cos\theta_o}{p_o^{2/3}H} = 0.54 \tag{4}$$

Eq. 4 is plotted in Fig. 5 together with Eq. 2. The latter expression would be valid only for the case of $m_a = 0$ but finite $m_o \cos\theta_o$ and is thus linked to the lower 45° sector of the plot. In that case the disagreement between both equations is given by the factor $(1 + \cos^2\theta_o)^2/(1 + \cos\theta_o)$ which takes on a maximum of 2 for $\theta_o = 0°$. However, comparison with extensive experiments in Fig. 5 indicates that despite this discrepancy Eq. 4 seems to be a good representation for diffuser near field stability in the general case of both discharge induced and crossflow induced destabilizing effects.

Several comments regarding Fig. 5 are in order. The scales on both axis are distorted by taking the fourth root of the parameters in order to display equally the stable and unstable range. Experiments on discharge stability in the presence of ambient crossflow have been performed by Cederwall (14), Jirka and Harleman (23), Buhler (13) and Roberts (39). In addition, some of the data on stagnant ambient conditions, already given in Fig. 4, has been included in Fig. 5. Among Cederwall's experiments on vertical discharges only those data points which he had labeled as "jet or plume-like patterns" were considered as stable near field. Stratified downstream conditions in other experiments are judged to be intermediate field phenomena as will be mentioned further below. The momentum in Roberts' experiments was computed by assuming a fully developed pure plume at the slot exit. Fig. 5 also includes the operating conditions (see Table 1) for sewage and thermal diffusers, with and without ambient flow, thus points "S", "SA" and "T", "TA", respectively. Even the otherwise stable sewage diffuser discharge experiences a local flow breakdown in the diffuser vicintiy under the effect of crossflow. This has been the result of the sewage diffuser studies by Buhler in a two-dimensional model and by Roberts in the fully three-dimensional domain.

In summary, these stability analyses demonstrate that thermal diffusers always have an unstable near field. Hence, analysis techniques which are altogether different from the simple buoyant jet theories for sewage diffusers (at least in the stagnant range) must be employed to determine the mixing capability of thermal diffusers. Note, however, that the near field instability relates to the immediate vicinity (of the order of several water depths) of diffusers. The flow field at larger distances can sometimes restratify due to intrusion processes. However, these are intermediate field processes - as analysed in later sections - which are governed by the overall larger scale geometry rather than the discharge characteristics. This aspect underlies inconsistencies seen in the earlier discharge stability criteria by Cederwall (14) and Argue and Sayre (9).

3. Major Types of Shallow Water Diffusers

Using merely two-dimensional analyses so far, we have shown that shallow water diffusers are dominated by their discharge momentum. Since momentum is a directed (vector) quantity, we must expect, therefore, that the diffuser dynamics in the general three-dimensional case (see Fig. 1) will critically depend upon how that momentum is introduced. This is controlled by the vertical (θ_o) and horizontal angle (β) of the diffuser nozzles. Using the line diffuser concept from now on (i.e. a slot diffuser with $B \rightarrow 0$), the diffuser boundary conditions for the three-dimensional problem are the three components of momentum and buoyancy flux which are variable along the diffuser axis

$$\vec{m}_o(y) \quad , \quad \vec{p}_o(y) \qquad \text{at } -\frac{L_D}{2} \leq y \leq \frac{L_D}{2} \tag{5}$$

in the coordinate system of Fig. 1. These and other boundary conditions together with the governing equations (e.g. the turbulent Reynolds equations) which are not stated here would give the general problem statement. No solutions to that general problem are presently known or easily derivable, even for simpler cases such as the unbounded ($x,y \rightarrow \pm\infty$), constant depth, stagnant shallow layer. Making yet another simplification, namely neglecting the buoyancy flux, $\vec{p}_o \rightarrow 0$, and hence the possibility of restratification in the intermediate field that has been alluded to earlier, allows one to formulate - by means of vertical integration - a purely two-dimensional problem with the two-component momentum vector

$$\vec{m}_o(y) \cos \theta_o \qquad \text{at } -\frac{L_D}{2} \leq y \leq \frac{L_D}{2} \tag{6}$$

as the diffuser boundary condition. This includes the tacit, yet tenuous, assumption that the vertical component of the momentum flux gets dissipated (rather than re-directed) in the near-field process (see Section 6). In any case, the ensuing governing equations (with appropriate bottom friction terms) would then describe a class of problems which may be labeled as "momentum induced circulations in a shallow fluid layer" (or, alternatively, in two-dimensional space) which has many corollories in classical fluid mechanics. In particular, scaling analyses of the equation indicate that for moderate distances, $(x,y)/L_D < 1$, frictional effects are indeed negligible, so that one may conceive of using fully inviscid flow theory, e.g. a superposition of line momentum sources (dipoles). Still, that approach has considerable pitfalls and leads to erroneous results as a later example will show.

Thus, a generally valid diffuser theory for arbitrary discharge conditions has not been established as yet. Instead, we will concentrate the further analysis on three special diffuser types which have emerged in design practice during the past decade. These types (see Fig. 6) are classified by their nozzle angles β and θ_o as: 1) Unidirectional diffuser, $\beta = 90°$, $\theta_o \approx 0°$. 2) Staged diffuser, $\beta \approx 0°$, $\theta_o \approx 0°$, and 3) Alternating diffuser, $\beta = \pm\beta(y)$, i.e. a variable orientation along the diffuser axis with every other nozzle pointing to a different side, θ_o = variable, i.e.not a preferred horizontal orientation. The important distinction between these types lies in the fact that, for a control volume enclosing the entire diffuser, the first two types have a net horizontal momentum input with strong induced currents, while the alternating diffuser has zero net horizontal momentum, with lesser induced currents whose magnitude will, presumably, depend upon $\beta(y)$. The performance of each of these types under the influence of an ambient current will depend upon the alignment angle, γ, between diffuser axis and current direction. We distinguish between two extreme cases: 1) Parallel diffuser alignment, $\gamma \approx 0°$, and 2) Perpendicular diffuser alignment, $\gamma \approx 90°$.

The following analyses for the three diffuser types have this common base: (i) Near-field is unstable. (ii) Constant ambient depth. (iii) No shoreline effect ($x,y \to \pm\infty$). (iv) Line diffuser approximation. (v) Stagnant conditions which, in terms of mixing, are the critical worst case are considered first, followed by an extension to crossflow conditions. Deviations from these common assumptions will be treated on an ad hoc basis.

4. Unidirectional Diffusers

Probably, the earliest designs for unidirectional diffusers in a coastal environment were for the FitzPatrick Station (45) on Lake Ontario and the Zion Station (28) on Lake Michigan. Unidirectional diffuser designs in rivers which pose rather different constraints were initially proposed for the Browns Ferry Station (46) on the Tennessee River and the Quad Cities Station (19) on the Mississippi.

4.1 Stagnant Ambient

Synopsis of the flow field: Detailed experimental studies (e.g. Fig. 7a) have shown that the "plume" - an intermediate field phenomenon in the present terminology - produced by a unidirectional diffuser has a distinct structure as indicated in Fig. 7b. In steady state the momentum flux at the diffuser line accelerates the ambient fluid from large distances behind the diffuser and also provides a pressure discontinuity across the diffuser line, i.e. the local surface elevation h^- upstream is depressed, $h^- < H$, and downstream, $h^+ > H$. Flow separation at thediffuser ends causes the flow downstream to accelerate even further, that is, the excess pressure head is converted into kinetic energy. Thus an acceleration zone, or "slipstream", is formed immediately downstream, much like a two-dimensional analog to the flow downwind from a propeller (e.g. Prandtl, 37). Although the slipstream motion is an essentially inviscid phenomenon, the plume is further affected in two ways by its real fluidcharacter. First, the velocity discontinuity at the slipstream boundary gives rise to lateral diffusion effects leading to side entrainment similar to ordinary jets. Second, turbulent bottom friction will lead to gradual dissipation of the plume momentum, and thus deceleration and ultimate stagnation. This provides the transition to far field processes. The unstable near field in Fig. 7 is that highly three-dimensional zone in which the individual jets (or the line jet) become vertically mixed over the water column. Its extent in the x-direction is about 5H to 10H (30) and thus negligible for long diffusers $L_D/H >> 1$. In total, the mixing characteristics of the diffuser are influenced by back entrainment, due to the bulk acceleration of the ambient fluid, and by side entrainment, due to lateral diffusion.

Slipstream analysis: Straightforward scaling (4, 30) of the governing vertically averaged momentum equations using L_D as the characteristic horizontal length scale and typical estimates for bottom friction and lateral diffusivities proves that the acceleration zone flow is, indeed, governed by inviscid dynamics. This raises an interesting temptation, namely to use potential theory with a simple superposition of dipoles of strength m_o/Hdy along $-\frac{L_D}{2} < y < \frac{L_D}{2}$. Integration gives then a potential flow field given by the consisting of two vortices located at the diffuser end, hence describing a recirculating flow. What is wrong with this model as it obviously does not agree with our observations (Fig. 7)? The answer is, of course, provided by basic boundary layer theory. Thus, the intense shearing action in the near field - here, in fact, the scaling length ought to be much smaller - generates sufficient vorticity that the decelerating and expanding flow which is implied by the two-vortex model cannot be sustained. The flow separates at the point of minimum pressure, that is, the diffuser end, and forms an entirely different downstream zone. However, that zone can be described again by inviscid theory, albeit with different boundary conditions and a different Bernoulli constant. An interesting analogy to the present situation is given by converging-diverging flow geometries such as an orifice in a pipe where a continuous potential flow theory fails and separation at the orifice throat is triggered by vorticity generation at the solid wall.

Adams (4, see also 30) was the first to analyse the contracting slip stream by using the elements of propeller theory (37), namely Bernoulli equations for the approach flow ($x < 0^-$) and the contracting flow ($x > 0^+$) and a momentum equation for the pressure discontinuity across the diffuser line ($0 < x < 0$). The result can be written as

$$u_N = \left(\frac{2\, m_o}{H}\right)^{1/2} \quad , \quad \sigma = \frac{1}{2} \tag{6}$$

where u_N and $L_N = \sigma\, L_D$ are the slipstream velocity and width at the fully contracted uniform downstream section. The total discharge in the slipstream is therefore

$$Q_N = \left(\frac{m_o\, H}{2}\right)^{1/2} L_D \tag{7}$$

and a bulk dilution S can be defined by relating Q_N to the discharge flow $Q_o = q_o L_D$ or to the excess temperature flux $J_o = Q_o \Delta T_o$ (a passive tracer in this case)

$$S = \frac{\Delta T_o}{\Delta T_N} = \frac{Q_N}{Q_o} = \frac{1}{q_o} \left(\frac{m_o\, H}{2}\right)^{1/2} \tag{8a}$$

where ΔT_N is the excess temperature of the slipstream. From a design viewpoint, it is often interesting to relate this to the manifold geometry

$$S = \left(\frac{\ell H}{2 a_o}\right)^{1/2} \tag{8b}$$

where $a_o = D^2 \pi / 4$ is the individual nozzle area. This one-dimensional theory does not give any further results on the slipstream properties. A detailed two-dimensional analysis was developed by Lee, Jirka and Harleman (30, 31) using a diffuser boundary condition of uniform velocities and uniform accelerations in the x-direction. A complex mapping transformation into the hodograph plane predicted the detailed geometry and velocity distribution. Most notably, the asymptotic slipstream values given by Eq. 6 are essentially approached within one half diffuser length, $x \approx L_D/2$, and the angle of separation at the diffuser end is 60° with respect to the x-axis. These results and the predicted slipstream velocity distribution appear to be in good agreement with observations (30) although sufficiently detailed exerimental data on slipstream properties still are limited.

The bulk dilution parameter S, Eq. 8, is therefore an important predictor for the initial back entrainment characteristics of a unidirectional diffuser. It is usually easily observed as it can be measured within a uniform temperaature plateau, ΔT_N, downstream from the diffuser. Existing observations agree well with theory as shown in Fig. 8.

Complete intermediate field plume: Even though the real fluid effects are of lesser importance within the initial acceleration zone, their incremental influence dominates the diffuser plume at larger distances. The analysis by Lee et al. assumes a boundary layer plume structure (see Fig. 9) in which the initial slipstream is surrounded by a narrow, but growing, diffusion zone until, at a distance x_I, the potential core region has been fully erased. The governing integral equation set is

$$\frac{dQ}{dx} = 2\,\alpha\, u_c H, \qquad \frac{dM}{dx} = \frac{dP_e}{dx} - \frac{\lambda}{H} M, \qquad \frac{dJ}{dx} = 0 \tag{9}$$

with the plume cross-sectional flux quantities defined as

$$Q = H \int_{-\infty}^{\infty} u \; dy, \qquad M = H \int_{-\infty}^{\infty} u^2 \; dy, \qquad \text{and } J = H \int_{-\infty}^{\infty} u \; \Delta T \; dy \tag{10}$$

In Eq. 9 P_e represents the integrated excess pressure which is evaluated from the slipstream solution and vanishes once the asymptotic condition has been reached ($x \gtrsim L_D/2$), λ is a friction factor related to f_o, the Darcy-Weisbach wall friction factor, $\lambda = f_o/8$, u_c the plume maximum velocity and α an entrainment coefficient. Assuming self-similar diffusion profiles of the Gaussian type, which, for $x < x_I$, are combined with constant core values, Eq.s 9 and 10 can be readily integrated to predict the plume evolution with distance x. Fig. 10 summarizes two important aspects of the solution, namely the plume momentum flux and volume flux, the latter scaled by the initial back entrainment value, Q_N. The solutions depend upon a friction parameter $\Phi = \lambda \frac{L_D}{H}$. Fig. 10a shows the initial increase in plume momentum in the acceleration zone and the gradual dissipation due to bottom friction. The frictional length scale x_f at which the diffuser momentum has decreased to 1/e of its initial value is

$$x_f/L_D \sim \Phi^{-1} \tag{11}$$

This loss of plume momentum also puts a limit on the additional side entrainment - for a regular momentum jet without bottom friction would entrain ad infinitum - which is given (if $x_f \gg x_I$) by

$$\frac{Q_{max}}{Q_N} \sim \sqrt{2}\left(1 + \frac{4\,\alpha}{\sqrt{\pi}\,\Phi}\right)^{1/2} \tag{12}$$

with $\alpha = 0.068$ for a momentum jet and the numerical values corresponding to the Gaussian profiles (30). For comparison, Fig. 10 also includes the behavior of a regular frictionless momentum jet with equal momentum flux, initial width L_D and discharge Q_N. Another effect of bottom friction is the increasing lateral growth of the plume.

These essential features of Lee et al.'s plume analysis are well verified by experimental data (30, 31). Of particular interest for environmental impact analysis is the prediction of excess isotherm areas, scaled by L_D^2, as given in Fig. 11 in which $\Delta T_N = \Delta T_o/S$. The plot shows good agreement and sensitivity to the frictional parameter Φ. The laboratory data describe relatively short diffuser lengths and hence lie below the theory for small A/L_D as the three-dimensional near field effects prevent a full vertical mixing of the plume and thus establishment of the expected temperature plateau. Fig.s 8 and 11 also give field data for the FitzPatrick Station, apparently the first coastal diffuser installation for which operating experience has become available.

A two-dimensional channel analysis: Some lessons about diffuser performance can be gleaned from the simple two-dimensional model that had been sketched in Fig. 3. This model has been used in an early diffuser study (18) to evaluate the diffuser mixing capacity. The analysis uses the energy equation for a streamline which commences far upstream and ends well downstream. The head losses along the streamline, as it passes through the channel, are balanced by the diffuser generated head differential. Thus, the diffuser acts much like a ducted axial flow pump. The predicted dilution is (23)

$$S_{2D} = \frac{1}{q_o} \frac{1}{\{1 + \sum k\}^{1/2}} (2\ m_o H)^{1/2} \tag{13}$$

which may be compared to Eq. 8a for the actual three-dimensional case. The constants in the wavy bracket are of interest: The value of unity is the exit loss coefficient, which describes the complete loss of channel flow energy once it re-enters the surrounding reservoir while $\sum k$ stands for the sum of the internal losses, such as entrance flow separation and internal friction. Analysis of channel laboratory data indicated that $\sum k = 0.25$ to 0.5. Thus, if we assume optimistically $\sum k \approx 0$, then the channel diffuser would have an initial, back entrainment related, dilution capacity twice as large as its three-dimensional analog. The poorer performance of the latter is, of course, due to the fact that a larger fraction of the diffuser energy is stored as kinetic energy in the high velocity slipstream and does not do useful back entrainment work. The more vigorous dissipation leads, however, to a more effective side entrainment process at larger downstream distances. In any case, if maximization of the initial bulk dilution is of interest for a given design, one might consider to "control" the slipstream contraction by placing guiding walls - possibly extending only over a fraction of the water depth - at both diffuser ends and even at regular intervals along the diffuser. No such designs have been made and their cost effectiveness remains to be studied. It is interesting to observe that qualitatively similar proposals for ducted propeller design have been made recently for more efficient energy extraction systems for wind (47) and ocean current energy (34). Another control possibility was explored by the writer (23), namely fanning out of the diffuser nozzles - roughly as indicated in Fig. 3 - to provide momentum in $\pm$ y-direction and thus counteract the contraction tendency. However, improvements in terms of the reduced dilution turned out to be marginal ($\approx$ 10%), much less than the optimal factor of two. This failure appears to be related to the natural tendency of diffuser induced circulations to "lock into" certain patterns as will be further discussed in Section 6.

Recirculation tendencies: From a large scale point of view the diffuser action in the constant depth fluid layer can be considered as a source-sink interaction. The source is given by the stagnation region, while the major sink exists at the diffuser line. This raises the possibility of recirculation, that is the return of heated water back to the diffuser and, hence, an unsteady temperature build-up. This problem was addressed by Lee et al. (32) using order of magnitude arguments. The results, show that the recirculation potential may be significant for laboratory studies in which the limited basin boundaries may impose another constraint. But it is of little importance in actual field applications where such far-field effects as heat loss and diffusion are acting much faster than the recirculative advection.

Restratifiction in the intermediate field: Thus far, fully mixed conditions have been assumed. In view of our earlier stability considerations, this clearly holds in the early portions of the plume. However, given the finite buoyancy flux, at some point a restratification must be expected to occur. The same criterion as the one which leads to Eq. 3, i.e. local Froude number of about 0.65, gives in terms of the integral variables a stratification condition

$$\frac{M(x)}{(Q(x)\ P_o H)^{1/2}} = 0.5 \qquad (14)$$

in which M(x) and Q(x) are the known solutions (Fig. 10) and $P_o = p_o L_D$. While plume restratification has been observed in Lee et al.'s and other experiments, the data is too inaccurate to allow a rigorous testing of Eq. 14. Even less is known about the evolution of the restratified intermediate field plume except for some qualitative observations which show strong lateral spreading much like the spreading of three-dimensional buoyant surface jets (22). For increasing depth H(x) the restratification tendency is even stronger (see Eq. 14). Field data from the FitzPatrick Station shows a rapidly restratifying plume due to a significant offshore slope.

4.2 Ambient Crossflow

Perpendicular alignment ("Coflowing" diffuser): The coflowing diffuser in which the nozzles are pointing into the same direction as the ambient crossflow, has qualitatively the same flow features as those under stagnant conditions. Its analysis - both for the slipstream and the complete intermediate field - follows the same principles. The result for the bulk dilution (4, 30) is

$$S_a = \frac{1}{2} V + \frac{1}{2} (V^2 + \frac{2 m_o H}{q_o^2})^{1/2} \tag{15}$$

in which $V = u_a H/q_o$ is simply the volume flux ratio between ambient and discharge flow. For V = 0, Eq. 15 reduces to the stagnant case, Eq. 8a. For strong crossflow, $S_a \approx V$, thus forced mixing, and the downstream slipstream contraction vanishes. Again, good agreement with experimental data has been found, which is indicated in Fig. 8 along with the stagnant case data. In a coastal current system whose velocity - but not flow direction - changes the bulk dilution is therefore variable according to Eq. (15). The performance of this diffuser alignment under tidal current reversals has been found (4, 18) to be very poor with intense temperature build-up zones occuring whenever the current opposes the nozzle direction.

River applications: The coflowing design is obviously the preferred design solution in riverine situations (28, 46). Here the effect of the lateral confinement of the shallow flow field becomes a crucial factor. The bulk dilution equation, Eq. 15, is applicable only if the diffuser does not extend across the entire river width. Under this condition, a local acceleration of the river flow is possible. The dilution capacity of a coflowing river diffuser is, ultimately, controlled by the available river flow Q_R. If the diffuser induced flow, $S_a Q_o$, is large, $S_a Q_o > Q_R$, then recirculation must take place, that is mixed water from the downstream region will return to the back entrainment region. The average dilution is then river controlled, $S_R = Q_R/Q_o$. This recirculation process has been observed in model studies related to the Browns Ferry plant (46). The river controlled condition always applies when the diffuser extends fully across the river as has been simulated in numerous simple laboratory experiments.

Parallel alignment ("Tee" diffuser): Diffuser design in coastal environments is often carried out with the objective of providing sufficient offshore momentum to "push" the discharged effluent away from the shoreline. This objective is well achieved with the tee diffuser design under (near) stagnant conditions but it leads to significant reductions of initial dilutions under the influence of stronger currents. This adverse behavior is caused by the 90° mismatch between discharge momentum and crossflow momentum. Two effects are responsible: First, a local bending and overlapping of the individual discharge jets, and second, a recirculating eddy in the lee of the diffuser plume which is caused by rapid deflection of the entire discharge plume as the fully mixed plume blocks the ambient flow. Experimental data on the initial dilution - which is often difficult to determine because of large non-uniformities and plume break-up - have been correlated with the momentum ratio m_a/m_o. Lee et al. (31) have concluded an insignificant effect on dilution for small crossflow, $m_a/m_o < 0.1$, but rapid dilution reduction beyond that value. Analysis over a wider data range by Adams and Stolzenbach (5) lead to an empirical factor r_S which gives the dilution reduction relative to the stagnant value S, Eq. 8,

$$r_S = \left(1 + 5\,\frac{m_a}{m_o}\right)^{-1/2} \tag{16}$$

No analytical support for Eq. 16 is available nor is it easily derived due to the complicated flow geometry with recirculation zones. An equally empirical base is used in the analysis by Lee et al. (31) of the intermediate field plume trajectory of the tee diffuser. Their model computes the plume deflection on the basis of an entrainment force and drag force mechanism.

While that is standard practice in the modeling of three-dimensional jets in unbounded crossflow, it must remain rather tenuous in view of the strongly modified shallow ambient current whenever the plume blocks it. Possible plume restratification further complicates the situation. Using fitted drag coefficients, reasonable agreement with observed experimental trajectories was found, but different experimental conditions may necessitate coefficient adjustment. Finally, it should be mentioned that the offshore distance of a tee diffuser is also a critical parameter. A "starved" condition may arise when the diffuser is located too close to shore so that not sufficient ambient flow can penetrate to satisfy the downstream side entrainment demand in the lee of the plume. A plume shoreline attachment similar to that observed for buoyant surface jets (22) may result then. Again, restratification, possibly accelerated by an offshore slope, would somewhat abate that concern.

5. Staged Diffusers

The first diffuser designs which employed the staged diffuser concept were for the San Onofre Station (27) on the Pacific Coast and the Perry Station (3) on Lake Erie.

5.1. Stagnant Ambient

Structure of the flow field: Experimental observation (e.g. Fig. 12a) suggests an intermediate field plume structure which is made up of two zones: an acceleration zone along the entire diffuser length in which the diffuser momentum is gradually imparted to the ambient fluid, and, beyond the diffuser, a deceleration zone in which further lateral diffusion and bottom frictional dissipation takes place. In both zones, it is a side entrainment process which leads to plume dilution, unlike the unidirectional diffuser. A short three-dimensional zone, again of order of 5H to 10H length, exists at the upstream diffuser end before the unstable vertically mixed conditions are attained.

Analysis of the acceleration zone ("staged diffuser theory"): Theoretical developments for the fully mixed acceleration zone, $0 \leq y \leq L_D$ - where $L_D \to \infty$ is possible in principle - have been given by Almquist and Stolzenbach (7, 8) and Lee (29), respectively. These references have used the entrainment approach with the assumption of self-similarity of lateral velocity and temperature profiles akin to the two-dimensional momentum jet. We will use here a different approach whose results seem to suggest that neither is self-similarity achieved for practical diffuser designs as the initial three-dimensional effects are of paramount importance nor is the analogy to the simple momentum jet entrainment process justified.

We first consider the asymptotic case of a true line source of vertically averaged momentum flux, m_o/H along the y-axis in two-dimensional space (or, equivalently, a plane source in three-dimensional space). Self-similarity is indeed possible (29) for this case as the only parameters to scale the lateral velocity profile u(x) at a given distance y are the constant flux m_o/H and y. However, what is the self-similar profile? Since at the centerline (x = 0) the diffuser is constantly imparting concentrated line momentum we expect infinitely high velocities there so that the analogy of the overall profile to the typical bell-shaped profile of simple jets is hardly appropriate. Therefore we use a superposition principle to estimate that velocity profile shape. Since the linear momentum profiles of individual sources of strength $m_o\, dy_1/H$, where dy_1 is a differential distance along $0 \leq y_1 \leq y$, are in the present situation simply additive, the total momentum profile can be obtained by simple integration from 0 to y. The main assumption made here is that lateral growth rate, $k = \frac{db}{dy}$, of the individual sources is equal to that for simple momentum jets in irrotational flow. This appears reasonable. For, consider the behavior of sources near the section of interest, $y_1 \pm y$: These sources produce a locally intense vorticity field and perceive the already existing large scale, and hence weak, plume features as approximately irrotational. Using a Gaussian velocity profile, $e^{-\frac{x^2}{b^2}}$, where b is a measure of the local width, the momentum profile at y due to a differential source at y_1 is, by virtue of momentum conservation, $\frac{m_o}{H}\sqrt{\frac{2}{\pi}}\, e^{-\frac{2x^2}{b^2}}\frac{dy}{b}$, with $b = k(y-y_1)$. Integration along the diffuser and taking the square root gives then the composite velocity profile

$$u(x,y) = \left(\frac{m_o}{H}\right)^{1/2}\left(\sqrt{\frac{2}{\pi}}\,\frac{1}{k}\right)^{1/2}\left[\int_0^1 e^{-\frac{2x^2}{k^2y^2(1-\eta)^2}}\frac{d\eta}{1-\eta}\right]^{1/2} \qquad (17)$$

with $\eta = y_1/y$. The last factor in Eq. 17, simply denoted as $I^{1/2}(\frac{x}{ky})$, includes an exponential integral for which tabulated solutions (2) or numerical integration are adequate. The function $I^{1/2}$ gives the self-similar velocity distribution for a true line ($B \rightarrow 0$) staged diffuser and has highly concentrated core velocities (see Fig. 13).

In practice, the infinitely large velocites do not occur because the line diffuser assumptions do not hold (finite B) and, even more important, each source element has an initial three-dimensional zone until full momentum distribution over the entire water depth is achieved. Either of these two effects can be represented by a virtual source distance y_v. Thus, as far as surface conditions are concerned, we simply assume that only sources from 0 to $(y-y_v)$ influence the surface velocity profile at y. (Note: A more detailed, but lengthier approach would be to perform a superposition in three-dimensional but vertically limited space with a line source along $x = 0$,

$z = 0$. The resultant infinite series expression would presumably predict the actual vertically non-uniform conditions with higher influences near the bottom as has been observed experimentally (7)). The only difference in Eq. 17 is that the upper limit on the integral becomes $(1 - \frac{y_v}{y})$. The resulting non-dimensional velocity profiles, denoted by $I^{1/2}(\frac{x}{ky}; \frac{y_v}{y})$, are plotted in Fig. 13. Thus, the shape of the local velocity profile is critically dependent upon the three-dimensional zone effects. For increasing distance, $(\frac{y_v}{y})^{-1}$, the profiles undergo a constant evolution from an initial Gaussian shape $(\frac{y}{y_v} \gtrsim 1)$ to the final self-similar shape $(\frac{y}{y_v} \to \infty)$. The centerline velocity grows constantly in the process. A completely analogous superposition approach can be applied to the temperature flux, an equally conserved quantity. In general, the single source excess temperature profile may be given by $e^{-\frac{x^2}{\lambda_s^2 b^2}}$ where λ is a spreading factor between velocity and temperature profiles, usually $\lambda_s \approx 1.4$. If this is neglected $(\lambda_s = 1)$, then the same non-dimensional profiles result for temperature, i.e. in Eq. 17 $u(x,y)$ is replaced by $\Delta T(x,y)$ and m_o by $j_o = \Delta T_o q_o$. This is assumed henceforth. (Note: If the excess spreading is not neglected then the temperature profiles are slightly depressed in the center and more spread out than the velocity profiles $I^{1/2}$. In particular, the centerline value for temperature would be $(\frac{1+\lambda_s^2}{2\lambda_s^2})^{1/2} I^{1/2}(0; \frac{y_v}{y})$, i.e. a small reduction by a factor of about 0.9.)

Using $k = 0.154$ (6, 41) as the appropriate spreading value for the single source Gaussian profiles, the centerline velocities and temperatures at the diffuser end, $y = L_D$, are given by

$$u_c \left(\frac{m_o}{H}\right)^{-1/2} = \Delta T_c \left(\frac{j_o^2}{m_o H}\right)^{-1/2} = 2.28 \; I^{1/2}\left(0; \frac{y_v}{L_D}\right) \tag{18}$$

Eq. 18 is plotted in Fig. 14 together with experimental data. Since the staged diffuser profiles tend to become highly concentrated along the axis without a well defined plateau, it is difficult to find these local maxima in experiments. Almquist and Stolzenbach used a very fine measurement grid around the diffuser. Their observed surface temperature values are in good agreement with Eq. 18. Other studies (3, 44) determined the maximum surface temperature outside some exclusionary mixing zone. These "averaged" observations lie below the theoretical predictions. Yet regardless which observation criterion is chosen, all data, including some velocity observations, indicate a clear trend of increasing intensification as the relative diffuser length L_D/y_v increases. In all of these comparisons, y_v has been taken as 7.5H ($\approx \frac{1}{k^*}$ H where k* is likely some average between two- and three-dimensional jet spreading). This clear trend which is further supported by direct inspection of Almquist and Stolzenbach's data for $y_v < y < L$ exists despite the fact that all of the available experiments have some slope, $dH/dy > 0$, which would tend to counteract the intensification process (see Eq. 18).

The theory can also be used to define a volumetric (bulk) dilution as the ratio of laterally integrated discharge to diffuser discharge. Using the virtual source shift again, this bulk dilution is

$$S = 0.35 \, \frac{(m_o H)^{1/2}}{q_o} \, \frac{I^*\left(\frac{y_v}{y}\right)}{1 - \frac{y_v}{y}} \tag{19}$$

in which $I^*(\frac{y_v}{y}) = 2 \int_0^\infty I^{1/2}(\frac{x}{ky}; \frac{y_v}{y}) d(\frac{x}{ky})$ and $(\sqrt{\frac{2}{\pi}}\, k)^{1/2} = 0.35$. Eq. 19 is also plotted in Fig. 14. Its asymptotic value at large distances $(\frac{y}{y_v} \to \infty)$ is

$$S = 0.67 \frac{(m_o H)^{1/2}}{q_o} = 0.67(\frac{\ell H}{a_o})^{1/2} \qquad (20)$$

and is practically approached for $y/y_v \gtrsim 3$ which is the range for most diffuser designs (L_D/y_v = 3 to 10). Interestingly, this value is considerably larger than the bulk dilutions predicted by the entrainment based theories which give a coefficient value of about 0.45 (8, 29). Unfortunately, no direct data are presently available to evaluate S.

In summary, it appears that the present theory which predicts an overall plume intensification within the staged diffuser acceleration zone is well supported by experimental evidence. It avoids the restrictions imposed by assuming overall similarity and, furthermore, overall entrainment characteristics similar to the simple momentum jet which has an entirely different internal force balance. Similar shortcomings in the use of constant entrainment hypothesis for boundary layer phenomena with variable force balances have been noted in connection with buoyant jet analysis (1, 24).

Complete intermediate field plume: Beyond the acceleration zone, $y > L_D$, the flow field gradually returns to a regular laterally diffusing plume flow. Bottom friction which had a negligible influence within the short acceleration zone becomes increasingly important. This is quite like the diffusion zone of the unidirectional diffuser, for which Eq.s 9 and 10 are the governing equations, except that $dP_e/dx = 0$ and x is replaced by y in the staged diffuser notation. In fact, the similar features at the end of the acceleration zones for the two diffuser types are striking: The bulk dilutions S are of thesame order, vis. Eq.s 8 and 20, and so are the widths, about 0.5 L for the unidirectional and about $2\sqrt{2kL_D} = 0.44\ L_D$ for the staged diffuser. Thus, after a short adjustment zone, of order $5(2kL_D) = 1.5\ L_D$, beyond the diffuser the intermediate field flows for the two diffuser type are expected to be practically indistinguishable. Lee et al.'s theory for the diffusion zone of the unidirectional diffuser as summarized in Fig.s 10 and 11, should hold as well for the staged diffuser. This is demonstrated for example in Fig. 15 which compares predicted and observed excess isotherm areas.

Additional considerations: The question of nozzle orientation with repsect to the diffuser axis has received some attention. In some designs a slight alternating pattern (e.g. $\beta = \pm 25°$ for the San Onofre diffuser) and some upward angle ($\theta_o > 0°$) has been employed. In all of these, cases the same concentrated plume features persist, as individual jets become quickly deflected toward the plume axis (27), and the dilution is largely unchanged from the fully staged ($\beta = 0$, $\theta_o = 0$) diffuser. Suggestions that the y-momentum component should be taken only as $m_o \cos \beta \cos \theta_o$ seem unwarranted as the momentum becomes simply redirected into the y-direction. The extreme cases in this spectrum were probably the generic designs studied by the author (23) who considered variable nozzle orientations with $\theta_o = 45°$ and with $\beta(y) = \pm 90°(1 - \frac{y}{L_D})$ and $\beta(y) = \pm \cos^{-1}(\frac{y}{L_D})$, respectively. Thus, in both designs the first nozzles had, in fact, no y-momentum whatsoever! Still, the ultimate flow degenerated into a slender plume along the diffuser axis with intense deflection of the initial jets. Observed temperatures at the diffuser end are indicated in Fig. 14 with symbols ◊ and -◊-, respectively, without taking any reduction of the total momentum. This is but another, yet different, case of a "locking into" of diffuser flow patterns despite seemingly contrary source conditions. Criteria for the actual control of these flow patterns will be developed in the next section.

The effect of variable depth, H(y), can be readily included in the above theoretical development. This has also been done by Lee (29) (using, however, the entrainment approach) who also discussed methods of discharge variations, $m_o(y)$, $j_o(y)$, to compensate for the increasing depth in case of an offshore slope. The position y of plume restratification in the downstream zone will be given by the same criterion, Eq. 14, (x replaced by y) that has been developed for the unidirectional diffuser. Again, increasing offshore depth will strongly promote restratifiction. Finally, we can use, Eq. 14, evaluated at $y = L_D$ together with the bulk flow expression, $S\, q_o\, L_D$, where S is from Eq. 20, to find a criterion of applicability for the fully mixed assumption within the acceleration zone. This criterion is

$$\frac{m_o}{p_o^{2/3} H} \geq 0.52 \qquad (21)$$

In a way, this equation might be considered as an alternative near-field stability criterion since the two-dimensional channel assumptions which lead to Eq. 2 are hardly justified for a staged diffuser. Data analysis by Almquist and Stolzenbach (8) seem to suggest an even higher critical value, (possibly up to 2), but that conclusion needs further testing as the only stratified observations come from a distorted scale model study with strong offshore slope (27).

5.2. Ambient Crossflow

Perpendicular alignment: This is the only alignment solution of interest in normal coastal situations as it combines good offshore transport of the diffuser plume during stagnant conditions with a good capture of longshore current flow from either direction. Since the diffuser momentum and ambient momentum act at a right angle to each other, it is reasonable to propose a vector addition of the two resulting bulk mixing effects, so that the total bulk dilution becomes by virtue of Eq. 20

$$S_a = 0.67 \frac{(m_o H)^{1/2}}{q_o} [1 + 2.23 \frac{V^2 q_o^2}{m_o H}]^{1/2} \tag{22}$$

where the square bracket expression represents the current induced mixing amplification. The factor $V^2 q_o^2 (m_o H)^{-1}$ can also be written as the momentum ratio m_a/m_o. Eq. 22 is compared in Fig. 16 with available data from several experiments. Brocard (11) has derived a somewhat different expression based upon an extension of an entrainment based staged diffuser model. However, the difference appears to be less than the considerable scatter in the experimental data which reflects to a large extent the different averaging techniques employed in these studies.

Brocard et al (12) have developed a model for the complete trajectory of a staged diffuser plume in crossflow, including the effect of restratification. Their model showed good agreement with available experimental data (12, 38), but includes several fitting coefficients and some of the same reservations may be raised that apply to Lee et al.'s (31) trajectory model for unidirectional diffuser plumes.

6. Alternating Diffusers

The alternating diffuser concept has been a traditional design solution for buoyancy dominated sewage outfalls into the ocean. Its first applications for power plant discharges were the Shoreham Station (18) and the Northport Station (17) diffusers, both on Long Island Sound.

6.1 Stagnant Ambient

Two-dimensional channel analysis: The dilution characteristics of a properly designed alternating diffuser are controlled by the restratification of the intermediate field flow just outside the unstable near field zone. Thus the bulk dilution is influenced by buoyancy effects rather than pure momentum effects as is the case for unidirectional and staged diffusers. We first explore this mechanism in the simpler two-dimensional channel framework (Fig. 3). For the alternating diffuser with nozzle angle $\theta_o(A)$ - or in the limit, the vertical discharge, $\theta_o = 90°$ - a symmetric flow field results. Detailed experimental data (21, 23) show an unstable near field consisting of a recirculating cell of approximate length 2.5H which is then followed by a stratified counterflow in the intermediate field (Fig. 17). The primary role of the near field is the dissipation of the excess momentum of the discharge. Hence the momentum flux m_o looses its significance as a dynamic parameter. The bulk mixing, i.e. the ratio of ambient entrained flow to discharge flow, $S = \frac{2q_1}{q_o}$, is rather determined by the stratified flow dynamics of the intermediate field. That is, given the buoyancy flux p_o as the remaining active element, what strength q_1 of the counterflow system is maintained in steady state against the opposing forces of bottom friction τ_b, interfacial friction τ_i and convective accelerations at the control points C? The answer is given by the classical Schijf and Schonfeld (42) stratified flow equations solved for equal counterflow (23, 24) and resulting in

$$S = (2F_H)^{2/3} \frac{p_o^{1/3} H}{q_o} \tag{23}$$

in which F_H = densimetric Froude number of the stratified counterflow and a function of friction and relative channel length, $F_H = f(\Phi_c = \lambda \frac{L_c}{H}, \frac{\lambda_i}{\lambda})$, in which $L_c = L - 2.5H$ and λ_i = an interfacial friction parameter. The maximum value of F_H occurs for zero counterflow length, $\Phi_c = 0$, and is given as a pure inertial control, $F_H = 1/4$. Increasing Φ_c decreases F_H and hence leads to reduced dilutions S. Eq. 23, in normalized form and assuming $\lambda_i/\lambda = 0.5$, is plotted in Fig. 18 along with experimental data obtained from a channel within a large surrounding basin (23, 24). A clear sensitivity to the intermediate field effects is evident.

Three-dimensional alternating diffuser with stratified flow field: If annihilation of excess momentum within the near field and a buoyancy driven exchange flow is the dilution mechanism for an alternating diffuser within bounding channel walls, can a similar mechanism be achieved in the three-dimensional unstable case with finite diffuser length L_D? An analysis (4) is given below which demonstrates that a special horizontal momentum distribution $\pm \vec{m}_o^*(y) \cos \theta_o(A)$, i.e. a variable nozzle alternating orientation $\pm \beta^*(y)$, must be maintained to insure stratified flow in the intermediate field. If the actual nozzle distribution deviates significantly from that special one, then instabilities which originate within the unstable near field become amplified and lead to vertically mixed horizontal circulation cells within each quadrant of the xy plane.

Consider the diffuser line with the surrounding unstable near field zone (total width ≈ 5H) shown in Fig. 19. Under stably stratified flow conditions in the intermediate field we expect a lower layer flow toward the diffuser line as indicated by the streamlines. An approximately equal, but reversed, flow pattern should result for the flowaway of mixed water within the surface layer. Assuming, in steady state, an approximately constant interface location at half depth and, as has been done above, neglecting friction in the diffuser vicinity (scale length L_D) allows a simple two-dimensional inviscid analysis. Taking uniform dilution along the diffuser line (because of uniform buoyancy flux), the total sink strength, μ_o, per unit depth and length is

$$\mu_o = 2Sq_o/H \tag{24}$$

Using complex notation $\xi = x + iy$, the potential due to a differential sink at ζ is $dW = -\frac{\mu_o i \, d\zeta}{2\pi} \log (\xi - \zeta)$ where $-i \frac{L_D}{2} \leq \zeta \leq i \frac{L_D}{2}$. Integration over the diffuser length gives

$$W = \frac{\mu_o}{2\pi} \left\{ i \log \frac{(\zeta + i\, L_D/2)}{(\zeta - i\, L_D/2)} \Bigg|_{\zeta - iL_D/2}^{\zeta + iL_D/2} + iL_D \right\} \tag{25}$$

The complex layer-averaged flow field in the ξ plane is after differentiation

$$\tilde{u} - i\tilde{v} = \frac{\mu_o}{\pi} \left[\tan^{-i} \frac{2\xi}{L_D} - \frac{\pi}{2}\right] \tag{26}$$

and evaluated at the diffuser line

$$\tilde{u}_D - i\tilde{v}_D = \frac{\mu_o}{\pi} \left[\tan^{-1} \frac{2\, iy}{L_D} - \frac{\pi}{2}\right] \tag{27}$$

This gives the angle $\beta^*(y)$ under which the flow approaches the diffuser line, $\cot \beta^* = \tilde{v}_D/\tilde{u}_D$, or

$$\beta^*(y) = \pm \cot^{-1} \left(\frac{1}{\pi} \log \frac{1 + 2y/L_D}{1 - 2y/L_D}\right) \tag{28}$$

The streamlines ψ corresponding to Eq. 25 and the intersecting angle β^* are plotted in Fig. 19.

The object of alternating diffuser control is now to orient the horizontal component of the discharge momentum $\vec{m}_o^*(y) \cos \theta_o(A)$ so as to oppose the momentum flux which is carried by the incoming entrainment flow. The vertical angle $\theta_o(A)$ must be kept below a certain maximum in order to have sufficient opposing momentum. For any streamtube of width $\Delta\psi = u_D H/2$ the incoming momentum is $\tilde{u}_D^2 H (2 \sin \beta^*)^{-1}$ while the opposing momentum is $m_o \cos \theta_o(A)(2 \sin \beta^*)^{-1}$ in which m_o = total diffuser momentum flux (one half to each side). Thus, by virtue of Eq. 24

$$\cos \theta_o(A) \geq \frac{S^2 q_o^2}{m_o H} \tag{29}$$

independent of y, and using Eq. 23

$$\theta_o(A) \leq \theta_o^{max}(A) = \cos^{-1}[(2 F_H)^{4/3} \frac{p_o^{2/3} H}{m_o}] \tag{30}$$

Eq. 30 is evaluated, taking the most extreme condition, a very short diffuser, $\Phi_c \to 0$, $F_H = 1/4$, that is operating just in the unstable domain, $m_o/(p_o^{2/3} H) = 0.54$ (see Eq. 2 for zero net horizontal momentum). The result is $\theta_o^{max}(A) \simeq 45°$. Larger angles are possible for more unstable conditions. Thus, an alternating diffuser with unstable near field should have a variable nozzle distribution $\beta^*(y)$ given by Eq. 28 and a vertical angle less than $\theta_o^{max}(A)$ in order to insure a controlled stably stratified flow in the surrounding intermediate field. No diffuser control is possible for vertically discharging ($\theta_o = 90°$) unstable diffusers. No diffuser control is necessary for stable near field diffusers nor do the nozzle angles, $\beta(y)$ or $\theta_o(A)$, matter much.

These theoretical proposals have been tested and verified (23) in a series of experiments conducted with an alternating half diffuser (x,+y half plane) with the x-axis along the basin wall. Fig. 20a gives a photographic sequence for an unsteady dye release into the steady state flow field, $\beta^*(y)$, $\theta_o(A) = 0°$: (i) The dye pulse enters through nozzles at the diffuser end and center, respectively, showing spreading in all directions. (ii) The dye pulse now occupies the entire diffuser length and has spread more. (iii) Shortly, after the dye has been stopped, the entire surface area (20H x 20H is shown, with the diffuser half length $L_D/2H = 12$) is occupied by dyed, but diluted, water giving an indication of the stratified flow structure. The temperature field for a similar experiment, $\beta^*(y)$, $\theta_o(A) = 45°$, is given in Fig. 21a. The surface isotherms show spreading in all directions from the diffuser line and vertical profiles at four points within the intermediate field demonstrate the stratified structure. The near field in these cases is strongly unstable (vis. Eq. 2) and represents the region where the excess discharge momentum is dissipated while opposing the entrainment momentum.

Having established the possibility of three-dimensional stratified intermediate field flow it remains to relate its bulk dilution to that which has been derived under the channel approximation, Eq. 23. This may be done on the basis of equivalent frictional effects in the intermediate field. For while friction has negligible effects on the flow dynamics (i.e. the shape of the streamlines in Fig. 19) it ultimately determines the magnitude of the flow (i.e. the value of the streamfunction). The total head loss due to bottom friction in the channel model is approximately

$$h_{f2-D} = \lambda \frac{L}{H} \frac{1}{g} \left(\frac{q_o S}{H}\right)^2 \tag{31}$$

assuming again a lower layer thickness H/2. The total head loss in the three-dimensional case for a streamtube along the x-axis is given by the integral

$$h_{f3-D} = \int_0^\infty \lambda \frac{1}{H} \frac{1}{g} \tilde{u}^2(x,0)dx \tag{32}$$

Substituting Eq. 26, gives

$$h_{f3-D} = \lambda \frac{L_D}{2H} \frac{1}{g} \left(\frac{q_o S}{H}\right)^2 \left[\left(\frac{2}{\pi}\right)^2 \int_0^\infty (\tan^{-1}\eta - \frac{\pi}{2})^2 d\eta\right] \tag{33}$$

in which $\eta = 2x/L_D$. The value of the definite integral is $\pi \ln 2$ (2). Similar relationships could be constructed for the head losses due to interfacial friction. Thus, comparing Eq.s 31 and 33, equivalent kinematic (dilution) and dynamic (head loss) effects in the intermediate field requires

$$L = 0.884\left(\frac{L_D}{2}\right) \tag{34}$$

For practical purposes, given the approximations involved, the total channel length should be of order diffuser length, a reasonable result, or in terms of the frictional parameters

$$\Phi_c \approx \frac{1}{2} \Phi \tag{35}$$

Data from three-dimensional diffuser experiments with nozzle control are also included in the normalized dilution diagram (Fig. 18). The dilution S is here evaluated at the edge of a near field mixing zone of area $A_m = 5HL_D$ around the diffuser line. The agreement is good, supporting the equivalency argument.

Additional temperature reduction in the intermediate stratified flow field: In the preceding stratified flow analyses a stable interface with no diffusion or entrainment has been assumed. Observations in the laboratory suggest, however, that additional slow mixing is taking place in the intermediate field which leads to further surface temperature reductions beyond the near field value. Data from basin experiments (23) is shown in Fig. 22 giving the non-dimensional temperature rise, $\Delta TS/\Delta T_o$, as a function of scaled isotherm area, A/A_m. The indicated experimental trend may be used for estimation purposes, but caution must be exercised as the experimental data, for large areas relative to the available basin size are affected by unavoidable transient effects. Furthermore, surface heat loss may also play a role in the temperature decrease. In summary, the alternating diffuser flow field experiences a smooth transition from the intermediate field to the far field processes which cause ultimate diffusion and dissipation of the excess heat.

Deviations from the controlled nozzle orientation $\beta^*(y)$: If the diffuser momentum input deviates significantly from the controlled condition, then stratified flow breakdown occurs and fully mixed horizontal circulations are generated. The sense of these circulations depends on the sense of the deviation. Consider first a deviation $\beta(y) > \beta^*(y)$, or in the limit $\beta = \pm 90°$, the "traditional" alternating diffuser design. Here, the diffuser ends have no momentum to oppose the entrainment momentum flux which approaches along the $\pm$ y-axis. Hence, an instability arises at the ends and a current is set up which sweeps in to meet the entrainment demand of the jets in the diffuser center. After mixing and transfer of some of the discharge momentum, this current then leaves as a vertically fully mixed flow perpendicular to the diffuser along the $\pm$ x-axis. This sequence is shown in Fig. 20b: Photographs (i) to (iii) show the fate of the dye pulse emitted from the diffuser ($\beta = \pm 90°$, $\theta_o = 0°$(A)) into the steady state flow field. The dashed lines have been drawn in to suggest the boundaries of the contracting plume motions. A recirculation cell is generated in each quadrant of the xy plane. Despite the geometry difference, this flow structure somewhat resembles that of the unidirectional diffusers: the "back entrainment" flow is simply squeezed into a narrow zone between the y-axis (x = 0) and the line at which complete vertical momentum transfer has been achieved (x = 5 to 10H). In fact, just as the unidirectional diffuser has an analogy in three-dimensional aerodynamics, i.e. the propeller, there exists a three-dimensional analogy here as well: multiple propulsion jets issuing from a bluff body, such as at the bottom of a rocket or VTOL aircraft. For example, Baines and Keffer (10) observed similar contracting motions for a 17 nozzle propulsion assembly. No simple bulk dilution theories are available for analysis as the irrotational assumption is surely not justified and significant losses occur within this complex motion. A similar lack of control is also indicated by a purely vertical, $\theta_o = 90°$, diffuser with unstable near field. This is shown by the temperature velocity arrows given in Fig. 21b: The vertically mixed flow (profiles 2 and 4) along the $\pm$ x-axes is evident. The small stratification elsewhere (profiles 1 and 3) is merely a gradual secondary restratification effect in the intermediate field. Thus, even though the initial discharge carries no horizontal momentum whatsoever, the shallow water instabilities ultimately cause a re-direction of that momentum and give rise to significant horizontal circulations! We must emphasize again, that this does not occur for stable near field diffusers: Observations by Liseth (33) and the author (23) only show a slight inward bending of the rising buoyant jets at the diffuser end, but otherwise a stably stratified flow field.

The second deviation of interest is $\beta(y) < \beta^*(y)$, or in the limit $\beta \to 0°$, the staged diffuser, or rather a "diffuser doublet" issuing into both $\pm$ y directions. Here, the maximum momentum mismatch exists in the diffuser center ($y \approx 0$) where the instabilities start and then degenerate into mean currents toward the diffuser end. Data for diffuser motions which meet $\beta(y) < \beta^*(y)$, but are not fully staged, have been mentioned earlier (vis. Fig. 14). Again, the diffuser induced motions experience a momentum re-direction - this time into the $\pm$ y-direction - which is initially triggered by the instabilities.

A convenient summary of these generic diffuser characteristics is provided in Fig. 23 for the first quadrant of the flow field. The figure illustrates that, within a continuous spectrum of shallow water diffuser designs, there are only three fundamental flow patterns: the "unidirectional" pattern with flow away perpendicular to the diffuser, the "staged" pattern with flow away parallel to the diffuser and, in between, the controlled "alternating" pattern with stratified flow away into all directions. Accumulated evidence has shown that the first two are clearly "lock in" patterns, that is, easily generated and readily maintained horizontal circulations. To what extent, the alternating diffuser pattern is a stable one that is resilient to some deviations from the optimal $\beta^*(y)$ or to dynamic perturbations is an obvious concern. The author's experiments which involved variable orientations and clearly had imperfections in the nozzle orientation (e.g. only a few nozzles) demonstrated that the stratified flow field was persistent over long time and even in presence of weak ambient currents. No breakdown motions occured if $\beta^*(y)$ was reasonably provided. Still, further refined study seems needed in view of some of the approximations which lead to the definition of $\beta^*(y)$ in the first place and to define permissible deviations from the optimal distribution.

6.2 Ambient Crossflow

Perpendicular alignment: As for the staged diffuser this is the preferred alignment in the open coastal environment. Again, a vector addition of the two asymptotic dilution effects is most reasonable, giving a crossflow dilution S_a

$$S_a = (S^2 + V^2)^{1/2} \tag{36}$$

in which S is given by the stagnant value, Eq. 23. Available data from both a channel model and the three-dimensional diffuser with nozzle control are compared to Eq. 36 in Fig. 24. Even though the predictions are slightly high, the additive effect assumed in Eq. 36 is borne out by the data. Incidently, this is in marked contrast to the behavior of strongly buoyant diffusers (with negligible discharge momentum) in crossflow as observed by Roberts (40) who found surface dilutions typically less than the minimum asymptotic value V. This is another documentation of the strongly modifying effect of an unstable diffuser near field (20). The unstable near field, of course, does not preclude restratification at some distance downstream from the diffuser which has, in fact, been observed for most of the three-dimensional cases reported on Fig. 24.

Parallel alignment: An alignment parallel to the current may be necessitated by special siting constraints, e.g. navigational requirements at the Cape Cod Canal Plant (16). The dilution performance is obviously reduced relative to the perpendicular alignment, a reduction of about 20% being typical (23).

7. Aspects of Diffuser Design

7.1 General Design Considerations

Diffuser design practice consists of finding an acceptable tradeoff between the economic costs and the environmental impacts of a diffuser installation. The major cost component is the construction cost of the underground pipeline, comprising the actual diffuser and its feeder line from the shore. For large installations construction costs (e.g. tunneling) may exceed $10,000 per foot so that for mile long pipelines total costs can easily surpass $100 million. This represents a large investment both in absolute terms and relative to the total plant cost. Lifetime operational costs, due to energy losses in long pipelines or for high discharge velocities, are an additional element.

We may divide the environmental impacts into those related to the induced temperature field and those related to the induced velocity field. The temperature factor which has traditionally received most attention, both by biologists and regulatory personnel and, in turn, by design engineers, is the near field temperature rise. This excess temperature value, ΔT_{max}, - for regulatory evaluation and enforcement reasons - is mostly defined at the water surface and may include a small exclusion zone ("near field mixing zone"). Even though a ΔT_{max} constraint is still the major target value in design practice much more attention has been given in recent years to a more holistic and ecologically meaningful evaluation of the temperature impact. Temperature parameters, such as larger scale surface area - temperature rise relationships, volume - temperature rise relationships, temperature rise - exposure time relationships, temperature rises at the bottom (benthic organisms), temperature rises at the shoreline (littoral organisms), recirculation effects into the power plant intake etc., are often of equal importance and may affect not only diffuser design but site selection as a whole.

On the other hand, the engineering community has given very little consideration to the diffuser induced velocity field and the resulting modification of the ambient coastal hydrography. The potential for this modification clearly exists for large scale installations (see Table 1) and depends on diffuser type. The major consequences relate to the altered transport characteristics of the coastal zone, as regards transport of passive biological species and, more importantly, of sediment. A more direct impact on navigation is another possibility. The effect on sediment transport, if any, is naturally strongly dependent upon type of substrate, offshore bathymetry and natural transport rates. We may visualize two specific mechanisms by which diffuser operation may disrupt the natural transport regime. (i) Littoral, wave induced sediment transport appears to occur in about equal portions within the actual breaker zone and within the shelf zone further offshore (Grant, personal communication). The transport distribution within the shelf zone itself depends strongly upon bathymetry. If the shelf is weakly sloping (typical on U.S. East or Gulf coasts) then significant transport can occur to large offshore distances until sufficient water depth has been reached. If the shelf is strongly sloping (as on the U.S. West coast), then the transport rate drops off rapidly with offshore distance. Thus, the likelihood of diffuser interaction with this natural transport mode, is related to the diffuser location relative to the active shelf zone. If the diffuser is located outside that zone (e.g. West coast diffusers) then very little affect is likely. On the other hand, if a weak slope dictates a diffuser location somewhere within the active shelf zone, then strong interaction is likely. The degree of interaction depends upon diffuser type. For example, a diffuser with strong offshore momentum, such as the staged type, may effectively capture a significant portion of the littoral sand transport and push it offshore, thereby possibly causing offshore accretion and downshore erosion. Wave induced bottom shear velocities on the shelf during a major East coast storm may be of the order of 5 to 10 cm/s (0.15 to 0.3 ft/s) (Grant, personal communication). This leads to strong sediment transport rates as ascertained by indirect observations which compare shelf conditions before and after such storms. Diffusers which produce strong horizontal circulations can readily set up local shear velocities of equal magnitude. Thus, the possibility of local erosion exists in addition to the offshore diversion of littoral transport. (ii) A second mechanism by which diffuser operation can even affect the near shore transport within the breaker zone has been mentioned by Raichlen (personal communication). The wave-current interaction with the net horizontal circulation produced by certain diffuser types will, in principle, lead to wave refraction and focusing. This, in turn, leads to imbalances in the wave energy density along the shoreline. For a diffuser with strong offshore momentum, the possibility exists for local sand accretion effects at the shoreline and the gradual formation of a tombolo.

Certainly, much additional quantitative work together with detailed field observations on operating diffusers is needed to assess the long term impact (say, over half a century of operation) on the coastal morphology. However, the potential for some impact is likely, at least for those diffuser types with strong net circulations. This should not be surprising in view of the fact that some of these diffusers are large engineering structures which - after mixing - produce flows of the order of very large rivers (31) entering the coastal zone. Thus, the long term sedimentary activity should not be unlike that at some river mouths or tidal inlets or around some engineering structures, such as artificial harbors, jetties or offshore islands.

Despite the aforementioned variety of environmental impacts, we will assume for purposes of the following design comparison that the major constraint is given by a near field temperautre rise ΔT_{max}. Also, in most cases, this assumption is adequate for the screening of initial designs. Given the predictions for induced temperature rises which have been summarized in the earlier sections, we can therefore derive equations for the length requirements L_D for the three diffuser types. Given a power plant with discharge Q_o, temperature rise ΔT_o, therefore $g'_o = \frac{\Delta\rho_o}{\rho_a} g = \beta_e \Delta T_o g$ where β_e = coefficient of thermal expansion, discharge velocity U_o and ambient depth H, these length requirements are:

Unidirectional diffuser (from Eq. 8):

$$L_D = \left(\frac{\Delta T_o}{\Delta T_{max}}\right)^2 2 \frac{Q_o}{H U_o} \tag{36}$$

Staged diffuser (from Eq. 18):

$$L_D = \left(\frac{\Delta T_o}{\Delta T_{max}}\right)^2 (2.28\ I^{1/2})^2 \frac{Q_o}{H\ U_o} \quad (37)$$

in which $I^{1/2}$ is plotted in Fig. 13 and is a weak function of diffuser length with typical values between 1.0 and 1.5.

Alternating diffuser (from Eq. 23):

$$L_D = \left(\frac{\Delta T_o}{\Delta T_{max}}\right)^{3/2} \frac{1}{2\ F_H} \frac{Q_o}{H^{3/2}\ g'^{1/2}_o} \quad (38)$$

in which $(2F_H)^{2/3}$ is plotted in Fig. 18 as a function of the friction parameter Φ with typical values between 0.45 to 0.55; i.e. F_H between 0.15 and 0.20.

The qualitative difference in the peak temperature value ΔT_{max} implied in these design equations must be kept in mind here. ΔT_{max} represents a slip stream temperature plateau for the unidirectional diffuser, a concentrated temperature maximum above the diffuser line (predominantly at its end) for the staged diffuser and a mixing zone of total width ≈ 5H surrounding the alternating diffuser line. Furthermore, the design equations are limited to the worst case assumption of stagnant (or very weak) ambient velocities. These differences will be further illuminated in the following design example.

7.2 A Design Comparison

We illustrate for a typical large diffuser installations the differences in near field mixing related length requirements and in various environmental impact measures. More detailed sensitivity studies which explore the parameter variability indicated by Eq.s 36 to 38 but limit themselves to the singular aspect of near field mixing have been given by Adams and Stolzenbach (5) and Paddock and Ditmars (36).

A 2000 MW nuclear power plant with the characteristics given in Table 1 is assumed together with a coastal bathymetry with an initially sloping bottom and a uniform shelf depth of 10m (33 ft) reached after a distance of 500m (1640 ft). These conditions (see Fig. 25) may be typical for U.S. East or Gulf coasts or the Great Lakes. The coastal currents have a maximum strength of 0.3 m/s (1 ft/s) allowing for both cases of reversing and one-directional currents. A maximum allowable near field temperature rise, ΔT_{max}, of 1.5°C (2.7°C) governs the design and corresponds to a diluton of 8.

The design parameters and environmental impact characteristics of the three diffuser types are summarized in Table 2 and Fig. 25. Temperature impacts are indicated by the surface isotherm areas associated with ΔT_{max} and 0.5 ΔT_{max}, respectively. Velocity impacts are indicated by the maximum induced velocities.

The unidirectional diffuser has usually the least length requirement. Its alignment is dependent upon the nature of the ambient current regime. For non-reversing currents (also in rivers) the coflowing alignment is the obvious one. For reversing, but weak, currents an offshore orientation (tee diffuser) is possible. In strong reversing current systems, however, any unidirectional design seems undesirable. Also when a tee diffuser design is chosen it may be appropriate to move the diffuser location an additional distance (200m in our example) offshore to provide sufficient space for the back entrainment flow and prevent a "starved" plume condition.

The staged diffuser has intermediate length requirements. It is interesting to note that the large scale mixing capacity, as indicated by the area of the $\frac{1}{2}\,\Delta T_{max}$ isotherm, is similar to that for the unidirectional diffuser which has the same horizontal momentum input. Under cross-currents the diffuser performs well and independently of current direction.

The alternating diffuser generally requires the longest diffuser section. Also the extent of the $\frac{1}{2}\Delta T_{max}$ isotherm is somewhat larger because of the lack of an intensive mixing action in the intermediate field. Using the perpendicular alignment as the obvious choice, the mixing characteristics in a reversing current system are excellent.

These length requirements for the three diffuser types have to be contrasted with the fundamental differences in their temperature and flow fields as summarized in Table 2 with various impact measures and qualitative comments. Finally, it must be stressed again that not the diffuser length, L_D, alone but rather the total pipe length, TPL, to shore is the major cost parameter. If the feeder pipe is long, due to local bathymetry or shoreline impact constraints, then the relative differences in total pipe length can become minor. In our present example, if the staged diffuser is taken as the average (TPL = 1250m), then the relative deviations are $\pm$ 40% for the alternating and unidirectional designs and, thus, reasonably modest when compared to the differences in diffuser length alone.

8. Conclusions

A summary has been given of the fluid mechanical characteristics - as derived from theory and experimental observation - of submerged multiport diffusers used for the disposal of cooling water from thermal power plants. First and foremost among these characteristics is the near field instability produced by such thermal diffusers in typical receiving water conditions. Rather than forming a distinct buoyant plume as is the case for sewage diffusers, the high discharge momentum of thermal diffusers leads to a flow breakdown with local recirculation zones and full vertical mixing. The flow and temperature fields at larger distances, in the interemediate field, are then critically dependent upon how the discharge momentum is introduced into the ambient fluid layer. Out of a spectrum of possible diffuser designs three major types have evolved. The unidirectional and the staged diffusers are designs which result in concentrated vertically mixed intermediate field motions. The alternating diffuser with nozzle control, on the other hand, generates a stratified flow field outside the unstable near field. Predictive techniques for these basic types have been summarized, both for the stagnant ambient case and for the additional influence of a current system. These techniques, together with an appreciation of the fundamentals of shallow water diffuser behavior, should be useful for the design engineer in tailoring a diffuser design to the specific needs of a heat disposal situation.

Numerous problem areas await further clarification. Some of these have been mentioned in the preceding sections. Perhaps most important is detailed operational data on field diffuser installations, not only to verify the predictive capabilities developed thus far but also to define the actual environmental impacts of these major engineering structures. For example, could such data indicate that the induced near field temperature rise which was the prime concern in the past might in fact be far less critical in an overall evironmental context than modification of the coastal hydrography and sediment transport patterns? Finally, considerable advances have been made in recent years in applying computer based higher order turbulence models to reasonably complex hydraulic problems. Yet no successful application to the shallow water diffuser case has been reported and the momentum boundary condition at the diffuser line clearly poses a special difficulty. Thus, the development of a general diffuser theory, valid for arbitrary diffuser and receiving water geometries, remains a challenge for the future.

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List of Symbols

A = area included by isotherm

A_m = $5 L_D H$ = area of near field mixing zone for alternating diffuser

a_o = nozzle cross-sectional area

B = equivalent slot width

b = local jet or plume width

D = nozzle diameter

F_H = densimetric Froude number of equal counterflow

F_s = $q_o(p_o B^3)^{-1/2}$ = densimetric Froude number of slot discharge

g = gravitational acceleration

g' = buoyant acceleration

H = ambient water depth

h_f = frictional head loss

$I^{1/2}$ = velocity distribution integral for staged diffusers

i = $\sqrt{(-1)}$

J = total kinematic heat flux

j = kinematic heat flux per unit length

k = jet or plume spreading coefficient

L_D = diffuser length

L = half-length of two-dimensional channel model

ℓ = nozzle spacing

M = total kinematic momentum flux

m = kinematic momentum flux per unit length

P = total buoyancy flux

P_e = excess pressure force

p = buoyancy flux per unit length

Q = total volume flux

q = volume flux per unit length

S = bulk dilution under stagnant ambient conditions

S_a = bulk dilution under ambient crossflow

TPL = total pipe length from shore

U_o = discharge velocity

u,v,w = three-dimensional velocities

u_c = jet or plume centerline velocity

V = q_a/q_o = volume flux ratio

x,y,z = Cartesian coordinate system with z upward

x_f = frictional distance for diffuser plume

y_v = virtual source distance for staged diffuser

α = entrainment coefficient

β = nozzle angle relative to diffuser axis

γ = diffuser alignment relative to crossflow

ΔT = excess temperature

ΔT_c = excess temperature at jet or plume centerline

ΔT_{max} = maximum induced excess temperature

$\Delta \rho$ = density difference

λ = bottom friction coefficient

λ_i = interfacial friction coefficient

Φ = $\lambda L_D/H$ = diffuser intermediate field parameter

Φ_c = intermediate field parameter for channel model

ρ = density

θ_o = nozzle angle relative to horizontal

$\theta_o(A)$ = nozzle angle for alternating diffuser

ξ, ζ = complex variables

Subscript

o = discharge condition at diffuser line (or nozzle)

a = ambient conditions

N = conditions within slipstream for unidirectional diffuser

Superscript

* = optimal controlled conditions for alternating diffuser

Table 1

Comparison of Typical Sewage Diffuser and Thermal Diffuser Outfalls Serving a Coastal City of 1 Million Population

Design Variable	Units	Sewage Diffuser	Thermal Diffuser
Total discharge, Q_o	m^3/s (ft^3/s)	8(283)	80(2825)
Relative density deficit, $\Delta\rho_o/\rho_a$	---	0.025 (fresh-salt water)	0.0025 ($\Delta T_o \approx 12°C[22°F]$)
Total buoyancy flux, P_o	m^4/s^3 (ft^4/s^3)	2(230)	2(230)
Discharge velocity, U_o	m/s (ft/s)	5(9.8)	5(9.8)
Total momentum flux, M_o	m^4/s^2 (ft^4/s^2)	40(4630)	400(46300)
Near field dilution requirement, S	---	$\gtrsim 100$	$\lesssim 10$
Ambient depth, H	m(ft)	50(163)	10(33)
Ambient velocity, u_a	m/s (ft/s)	0.3(1.0)	0.3(1.0)
Diffuser length, L_D	m(ft)	500(1640)	500(1640)
Distributed momentum flux, $\frac{M_o}{L_D H}$	m^2/s^2 (ft^2/s^2)	0.0016(0.017)	0.08(0.85)
Order of magnitude of induced velocities, $0\{(\frac{M_o}{L_D H})^{1/2}\}$	m/s (ft/s)	0.04(0.1)	0.3(1.0)

Table 2

Diffuser Design Comparison: Summary of Environmental Impact Measures

DIFFUSER TYPE	STAGNANT OR NEAR-STAGNANT				AMBIENT CURRENT		
	Temperature exceedance areas		Induced velocities	Comments	ΔT		Comments
	ΔT_{max} = 1.5°C (2.7°F)	$\frac{1}{2}\Delta T_{max}$ = 0.75°C (1.4°F)			u_a = 0.1 m/s (0.3 ft/s)	u_a = 0.3 m/s (1 ft/s)	
UNIDIRECTIONAL	< 3 ha (7 ac) Fig. 11	35 ha (85 ac) Fig. 11	0.63 m/.s (2.1 ft/s) Eq. 6	Concentrated vertically fully mixed flow field. Bottom temperature impact.	1.3°C (2.3°F) Eq. 15*	0.9°C (1.7°F) Eq. 15*	*For coflowing design (suitable for non-reversing conditions). Tee design unsuited for current conditions.
STAGED	negligible	45 ha (110 ac) Fig. 15	0.63 m/s (2.1 ft/s) Eq. 18	Concentrated vertically fully mixed flow field. Bottom temperature impact.	0.7°C (1.3°F) Eq. 22	0.4°C (0.7°F) Eq. 22	Suitable for current reversals.
ALTERNATING	6 ha (15 ac) Fig. 22	120 ha (300 ac) Fig. 22	small	Stratified flow field. Minimal bottom temperature impact.	0.7°C (1.3°F) Eq. 36	0.3°C (0.5°F) Eq. 36	Suitable for current reversals.

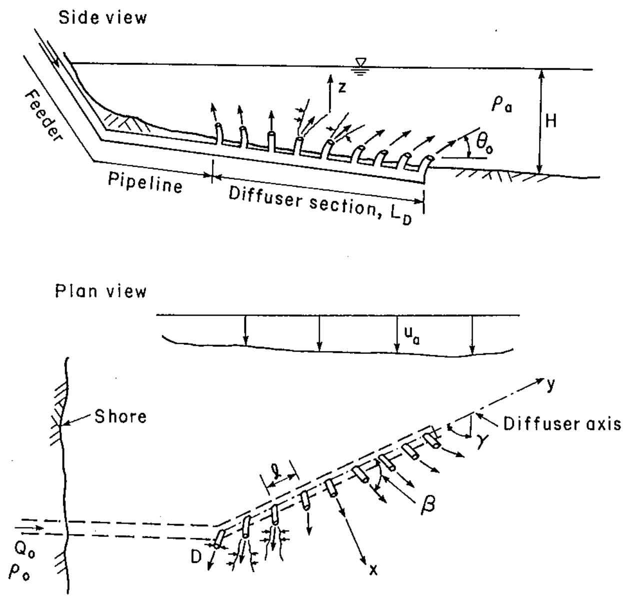


Figure 1. Submerged Multiport Diffuser: Definition Diagram

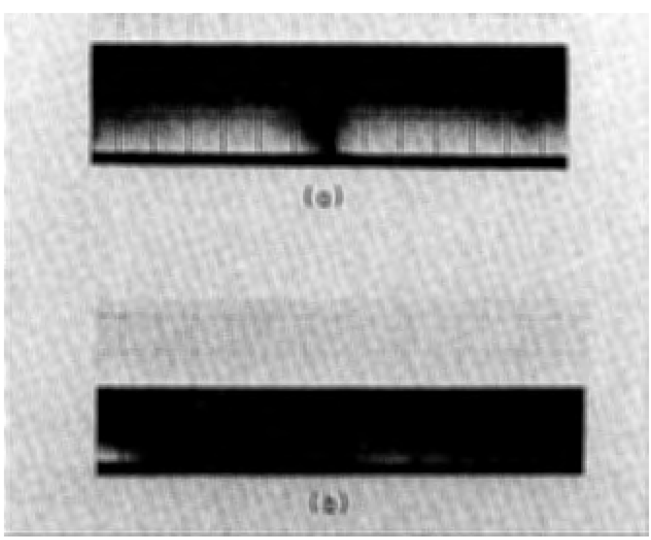


Figure 2. Vertical Buoyant Line Jet Discharging Into Finite Depth. a) Stable Discharge Configuration. b) Unstable Discharge With Recirculation Zone. (From 24).

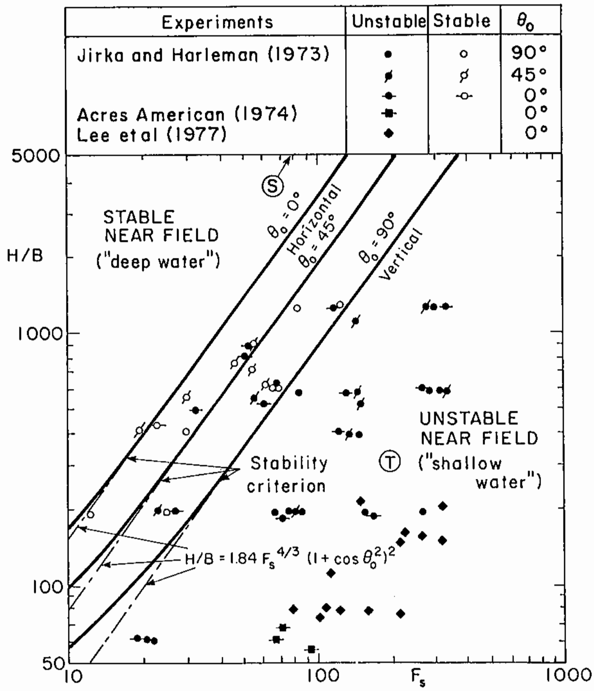


Figure 3. Two-Dimensional Channel Approximation of General Three-Dimensional Diffuser Flow Field.

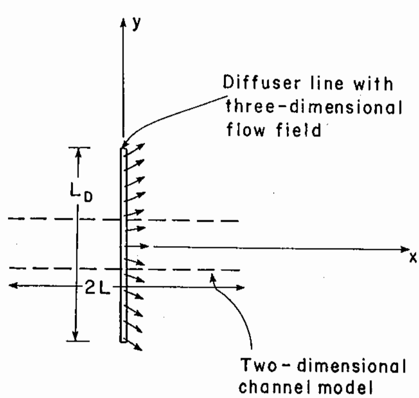


Figure 4. Stability Diagram for Line Buoyant Discharges Into Confined Stagnant Ambient.

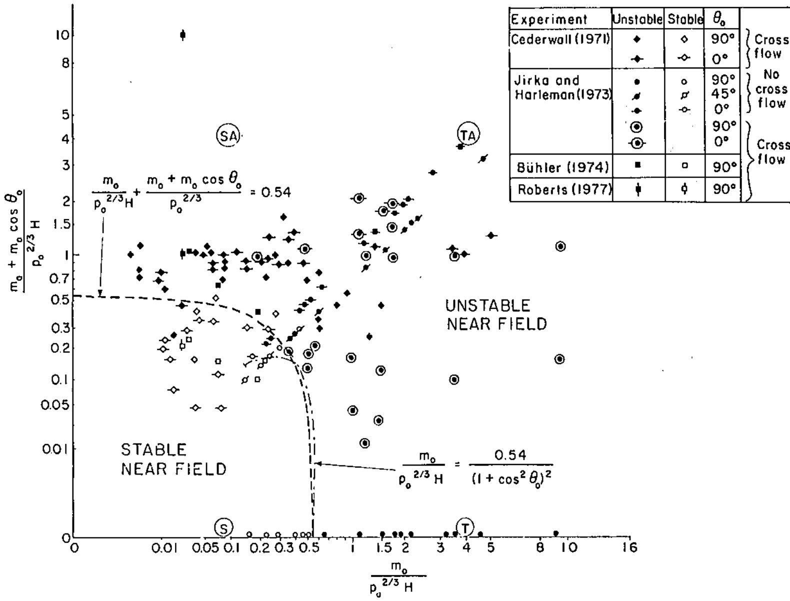


Figure 5. General Stability Diagram for Line Buoyant Discharges Into Confined Depth Comprising Stagnant and Flowing Ambient.

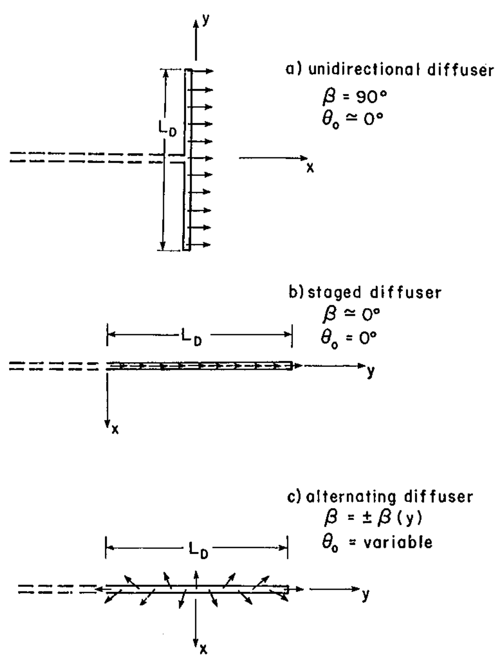


Figure 6. Nozzle Geometries for Three Major Diffuser Types.

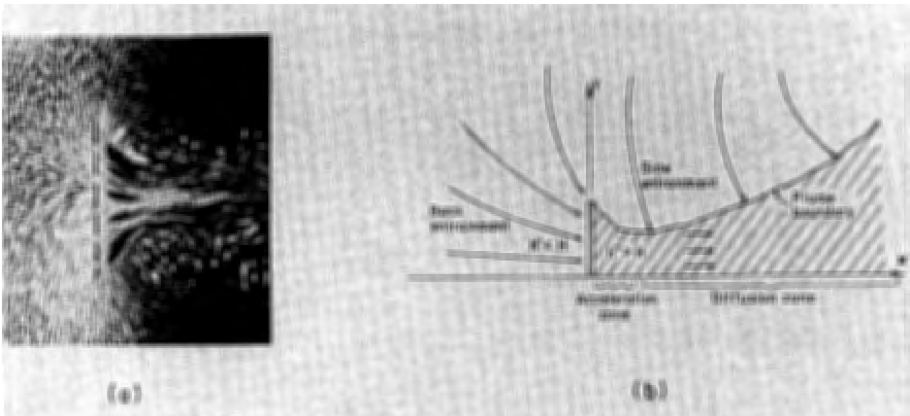


Figure 7. Flow Field Induced by Unidirectional Diffuser: a) Surface Flow Pattern Observed In Experiment (Adapted From 7, 30). b) Structure Of Diffuser Plume.

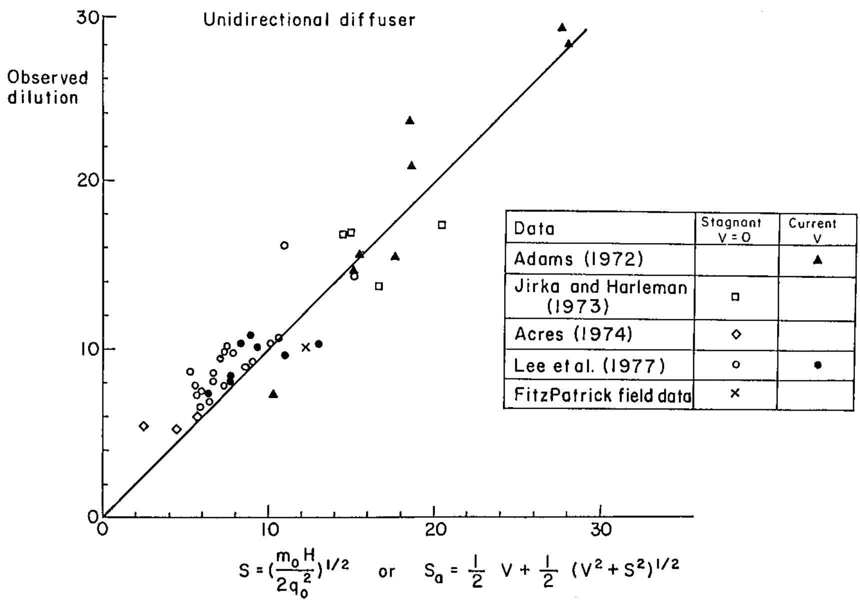


Figure 8. Unidirectional Diffuser: Comparison Of Observed and Predicted Bulk Dilution for Stagnant (S) and Flowing (S_a) Ambient.

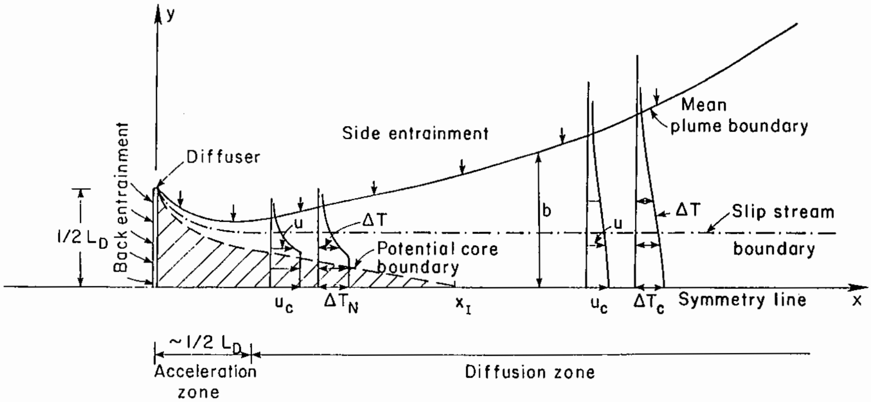


Figure 9. Details of Intermediate Field Plume For Unidirectional Diffuser.

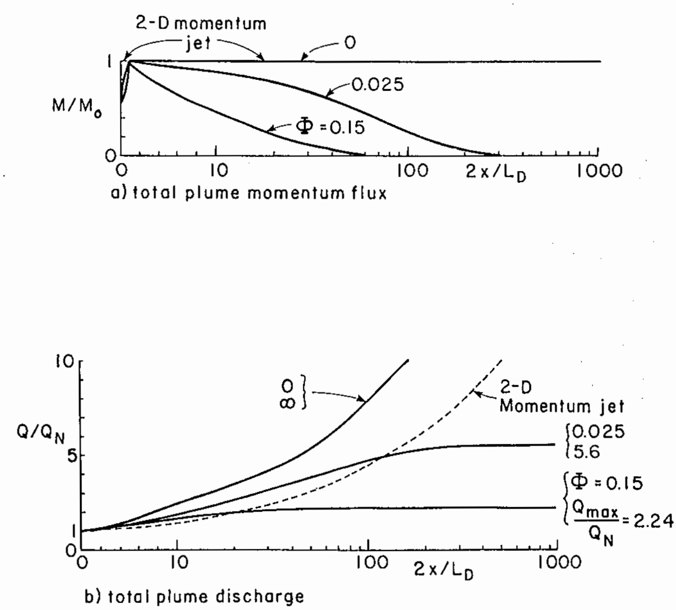


Figure 10. Momentum Flux and Discharge Within Intermediate Field Plume of Unidirectional Diffuser. (From 30)

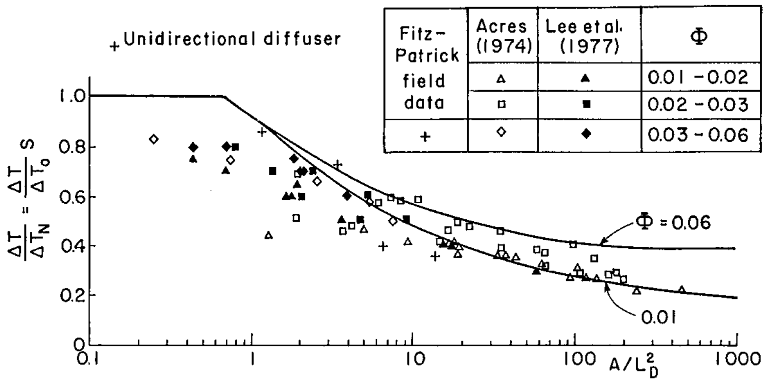


Figure 11. Unidirectional Diffuser: Comparison of Observed and Predicted Excess Isotherm Areas for Stagnant Ambient.

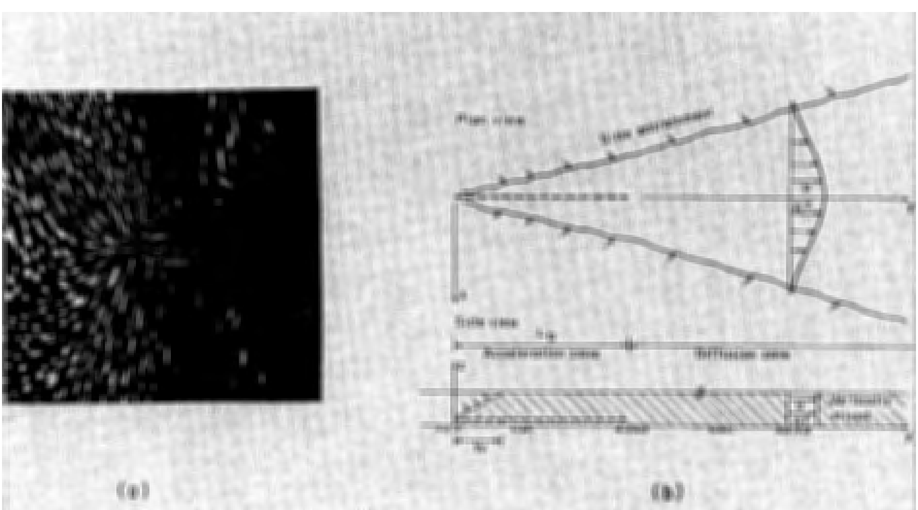


Figure 12. Flow Field Induced by Staged Diffuser: a) Surface Flow Pattern Observed in Experiment (Adapted From 7, 8). b) Structure of Diffuser Plume.

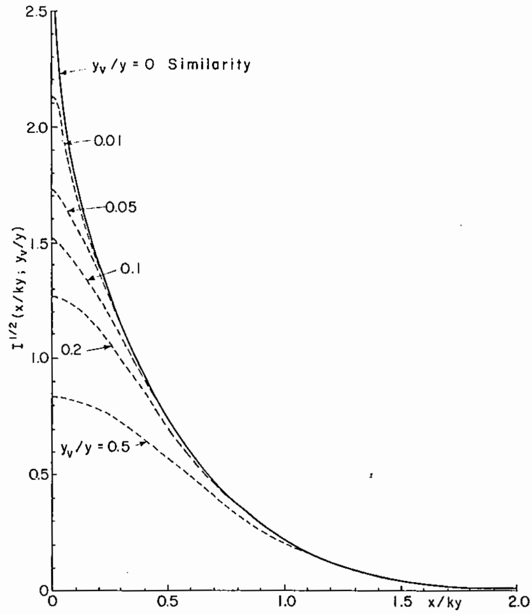


Figure 13. Staged Diffuser: Normalized Lateral Velocity Distributions. Solid Line Gives Asymptotic Self-Similar Distribution, Eq. 17; Dashed Lines Give Evolving Distributions With Initial Virtual Source Effect.

Data	Velocity	Temp	Comments
Acres (1974)	•	o	Temperatures at edge of exclusion area
Stolzenbach et al. (1976)	▲	△	
Almquist and Stolzenbach (1976)		+	Centerline temperatures
Jirka and Harleman (1973)		◇ ◇	Variable $\beta(y)$ orientation

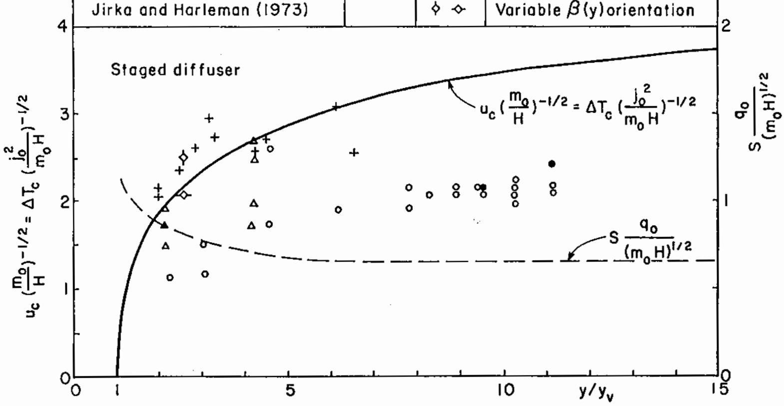


Figure 14. Staged Diffuser: Comparison of Predicted and Observed Centerline Temperatures and Velocities, Respectively, and Prediction of Bulk Dilution.

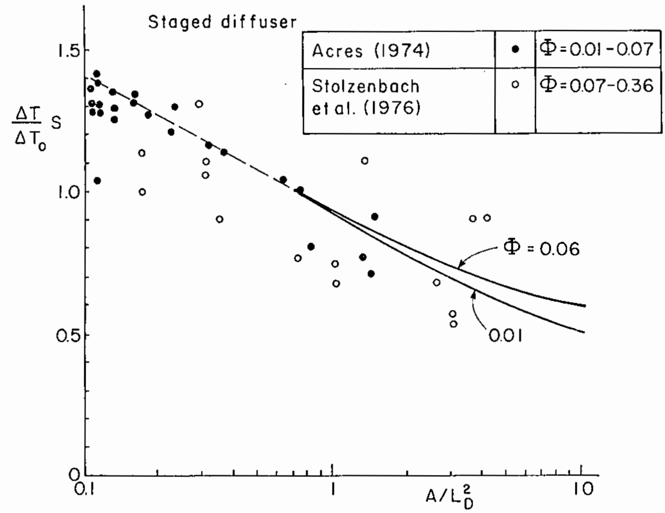


Figure 15. Staged Diffuser: Comparison of Observed and Predicted Isotherm Areas for Stagnant Ambient.

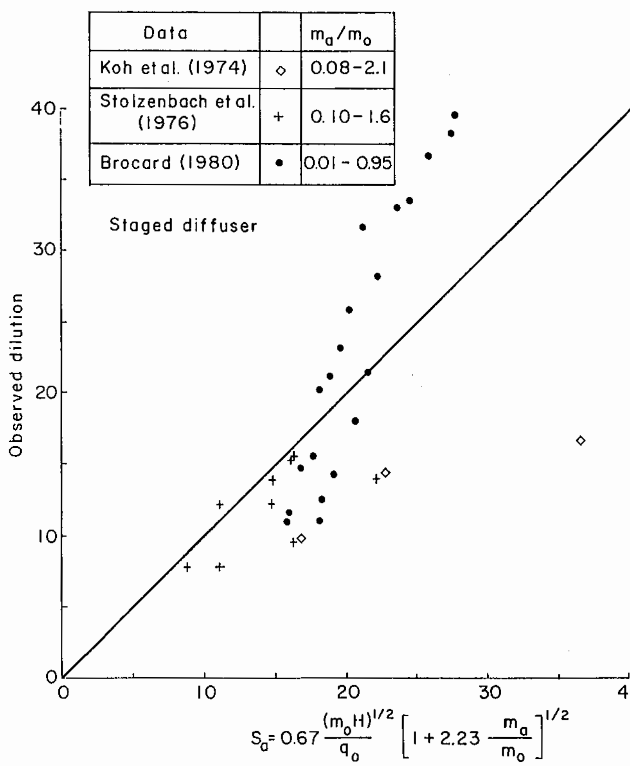


Figure 16. Staged Diffuser: Comparison of Observed and Predicted Dilutions Under Ambient Current Conditions.

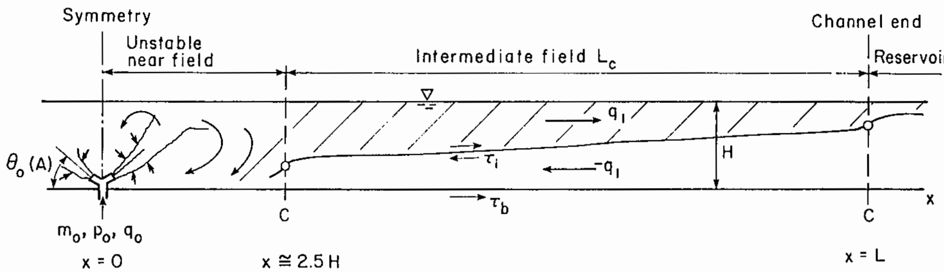


Figure 17. Alternating Diffuser: Stratified Counterflow Characteristics In Two-Dimensional Channel Model.

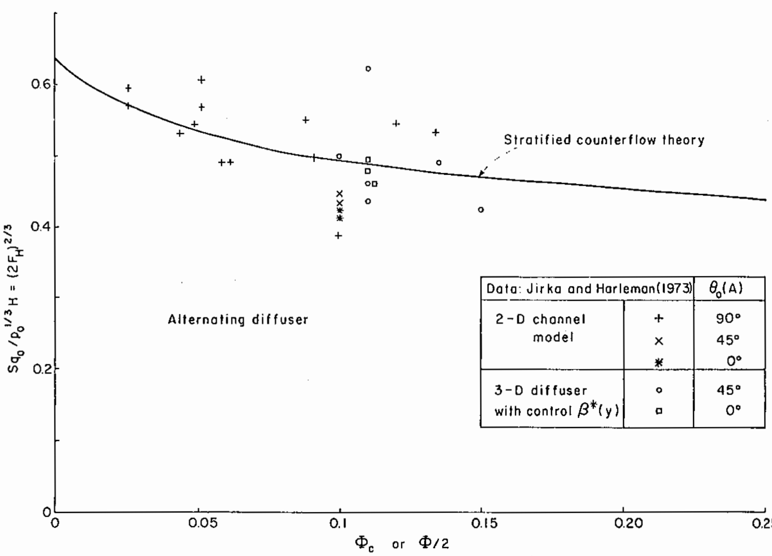


Figure 18. Alternating Diffuser: Predicted Dilutions In Comparison With Experiments in Two-Dimensional Channel (Φ_C) and With Controlled Three-Dimensional Diffuser ($\Phi/2$).

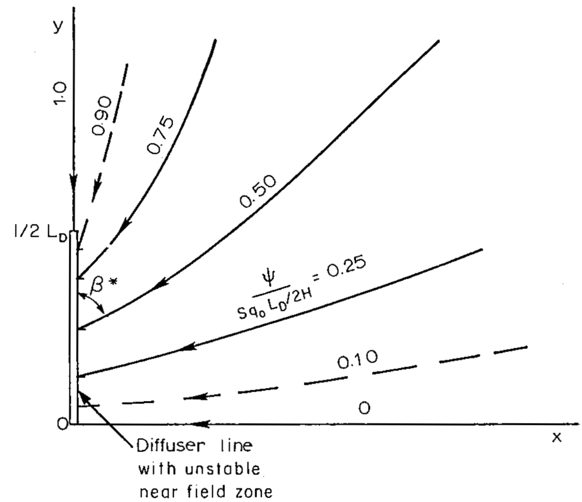


Figure 19. Sink Flow Velocity Field In Lower Layer of Alternating Unstable Diffuser With Nozzle Control.

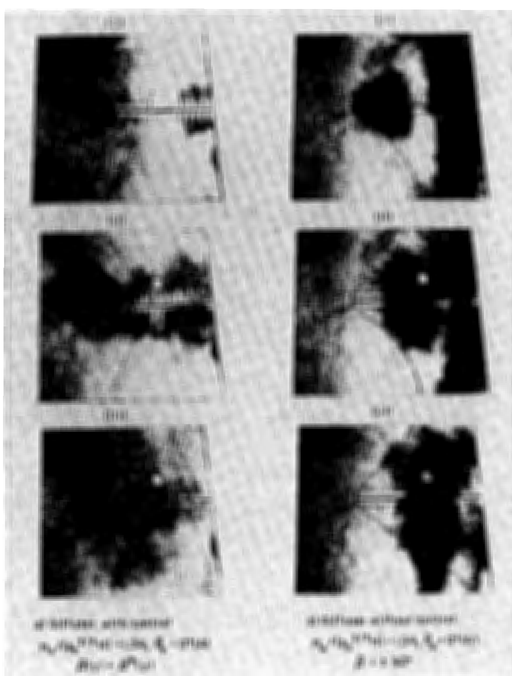


Figure 20. Alternating Diffuser: Effect of Nozzle Control Demonstrated By Dye Release Into Steady State Flow Field In Half Plane. a) Diffuser With Control. b) Diffuser Without Control.

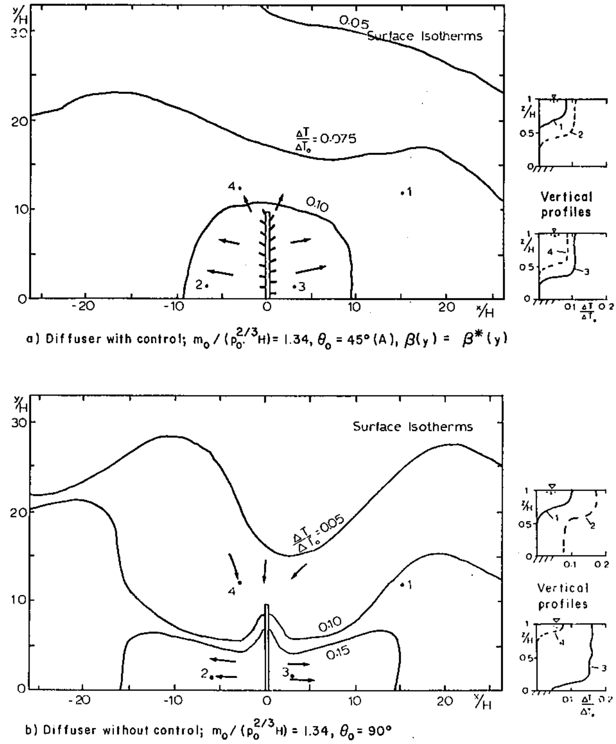


Figure 21. Alternating Diffuser: Effect of Nozzle Control on Temperature Field. a) Diffuser With Control. b) Diffuser Without Control.

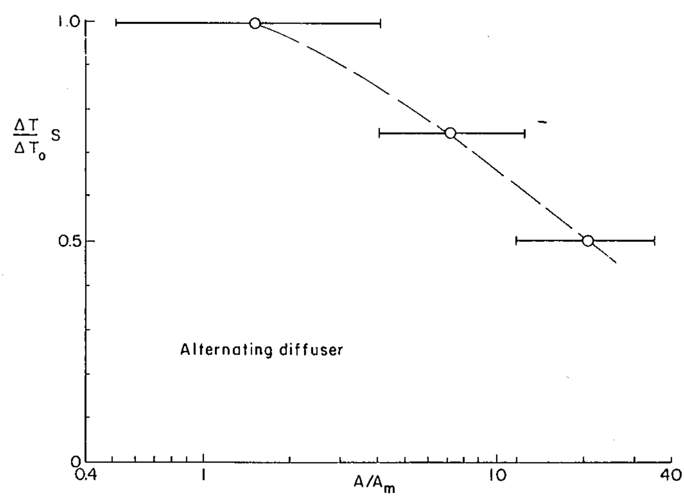


Figure 22. Alternating Diffuser: Additional Temperature Reduction In the Intermediate Field. Experiments By Jirka and Harleman (23).

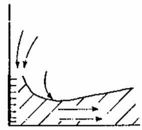
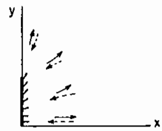
Diffuser Input of Horizontal Momentum	Nozzle Characteristics	Flow Field in First Quadrant	Comments
Deficit of y-momentum	$\beta(y) > \beta^*(y)$ or $\theta_0(A) > \theta_0^{max}(A)$		Fully mixed counter clockwise circulation; similar to "unidirectional diffuser"
"Diffuser control" Balanced y-momentum	$\beta(y) = \beta^*(y)$ and $\theta_0(A) < \theta_0^{max}(A)$		Weak stratified counterflow in all directions; "alternating diffuser"
Surplus of y-momentum	$\beta(y) < \beta^*(y)$ and $\theta_0(A) < \theta^{max}(A)$		Fully mixed clockwise circulation; "staged diffuser"

Figure 23. Generic Flow Fields For Shallow Water Diffusers As a Function of Discharge Momentum Distribution.

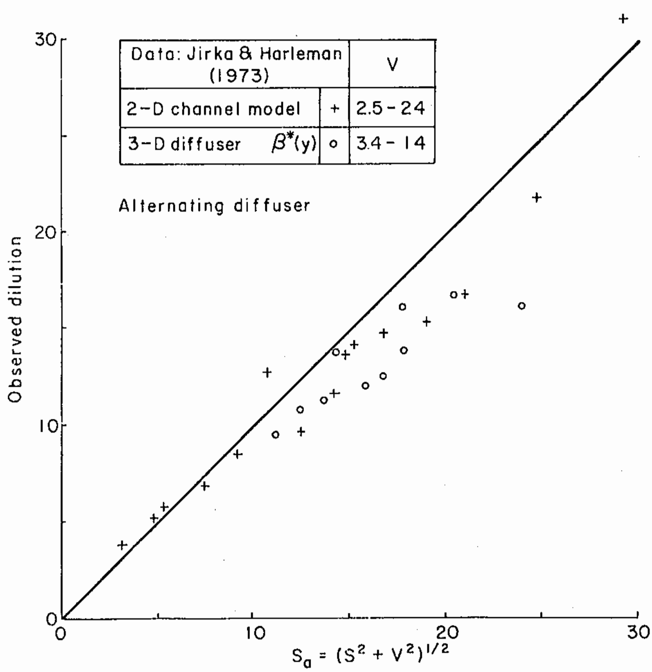


Figure 24. Alternating Diffuser: Comparison of Predicted and Observed Dilutions Under Ambient Current Conditions.

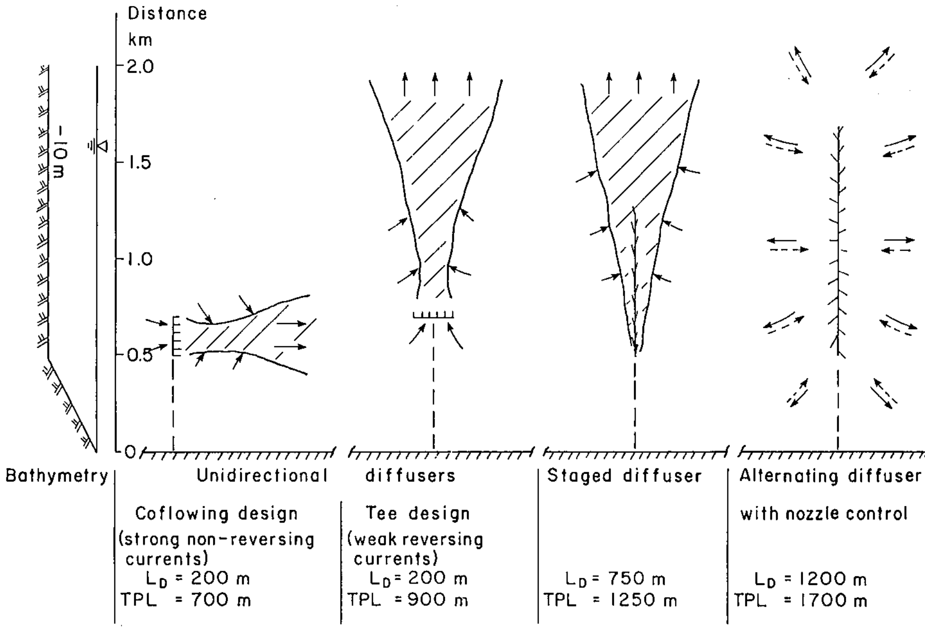


Figure 25. Design Comparison For Diffusers In Coastal Environment.

THE CHARLES RIVER BASIN

Remarks by H. Hobart Holly, Chairman of the History and Heritage Committee, Boston Society of Civil Engineers Section / ASCE, at the dedication of the Basin as a National Historic Civil Engineering Landmark, November 5, 1981.

Boston — famed for the bean, the cod, and the Charles River Basin. The engineering profession has not yet claimed credit for numbers one and two; but we point with great pride to number three.

A most noteworthy feature of this National Historic Civil Engineering Landmark designation is that it is not for the dam, or any other element of the Charles River Basin, but for the project as a whole — the remarkable transformation of a serious liability into a major asset — Boston's centerpiece as it has been called.

The problem was a very serious and a very complex one, involving health, environment, social considerations, commercial considerations, politics, freshwater problems, saltwater problems. The engineering profession had a challenge from the medical and public health disciplines, and met it with distinction. To eliminate a large area of severely polluted waters and tidal mud flats in the heart of a city would have been a major engineering accomplishment in itself. Also, the creation of a large constant-level freshwater basin of outstanding beauty and recreational value would likewise have been a notable accomplishment. The combination represents the highest plane of achievement in any professional endeavor — not just correcting bad conditions that man has brought on himself, but also creating positively for the benefit of mankind.

Many elements of the Charles River Basin Project could be singled out for praise. Two were outstanding. The first was the contribution of John Ripley Freeman. It was he who conceived and design-engineered the Charles River Basin. The so-called Freeman Report of 1903 still stands as a model for engineering reports. It set a standard for soundness, thoroughness, and environmental considerations far ahead of its time. The second was the contribution of Frederic Pike Stearns, the Engineer in Charge of the construction. He was largely responsible for coordinating the engineering with the landscape architectural design to arrive at the spectacular result that we see today. Mr Stearns' subsequent engineering structures were notable for the way they were blended aesthetically into the environment. There is a legacy of his experience here.

It is to be noted that each of the distinguished gentlemen whom we honor today was a member and President of the Boston Society of Civil Engineers and also served as President of the American Society of Civil Engineers.

We hope that the designation of the Charles River Basin as a National Historic Civil Engineering Landmark will lead to greater appreciation of it, and proper recognition of the contributions of the engineers and others who created it.

Ed. Note: The ceremonies dedicating the Charles River Basin Project as a National Historic Civil Engineering Landmark were held at the Boston Museum of Science where the plaque is permanently located. The plaque was presented by Dr. James R. Sims, President of ASCE, to Dr. Terrance J. Geoghegan, Commissioner of the Metropolitan District Commission that has care of the Basin.

A feature of the occasion was the presence of descendants of John R. Freeman, and the announcement of the special Charles River Basin issue of the BSCE Section Journal by Mr. Lee M. G. Wolman, Chairman of the Section's Committee for the John R. Freeman Fund. Copies of the special issue, which includes the Freeman Report of 1903, may be obtained through the Section office.

PLANNING THE MASSACHUSETTS WATER SUPPLY

By Paul W. Prendiville[1]

The press and the scientific communities are concerned with the long-term effects on the public's health of chlorinated organics and of synthetic organics in drinking water. The concern is justified, especially where synthetic organics are present in surface and groundwater supplies. On the other hand, we do not want the public to think that all water coming from their taps is polluted or even potentially harmful. Most water supplied to consumers in our country is not only fit for public consumption; the water is clear, tasteful and *healthy*.

Water is in fact one of the most economic and natural medicines a doctor can prescribe. Eight full glasses of water a day flushes our vital organs of their impurities. For already healthy individuals water keeps the systems flushed, and together with a regular minimum exercise regimen and judicious diet, many of man's chronic and minor ailments can be prevented. In addition, when ailments do occur, flushing with water can rid the internals of disease-causing organisms and impurities.

So, we should not be discouraging the maximum use of water for drinking, bathing and other domestic uses; rather we should ensure that the water reaching the public's taps is adequately disinfected and that it is pleasing to the eyes, nose and mouth. But, another problem exists, that of furnishing *enough* water to the public. The early 1980's brought to the Northeast the realization that public supplies are not adequate during extended periods of even average precipitation. But, we cannot nor should we discourage the use of water for drinking and bathing. We have a mandate to serve the public with the best water possible, and we must plan our water systems to provide a plentiful supply of potable water, even during the driest of years.

We must also provide sufficient waters for fighting fires, for irrigation of crops, forests and parks, and for non-potable uses in the home and in commercial and industrial establishments. But, the time has come to differentiate between the uses put to our waters. It does not make sense to allow large amounts of our pure upland surface waters and our clean groundwaters to be used for irrigation and industry. These waters should be conserved for potable uses.

The upland supplies of northern New England, the Quabbin supply serving the MDC and the Cobbler Mountain supply serving Metropolitan Springfield are all examples of good quality surface waters that can

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[1]Senior Vice President, Camp, Dresser & McKee, Inc.

continue to provide, with augmentation, disinfection and filtration, sufficient potable water for years into the future. The augmentation of Quabbin waters with diversions from the Connecticut River will provide enough potable and much of the non-potable water required in the State. Along with the augmentation of this supply, it would make sense to begin developing plans for using bodies of water like the Merrimack River for industry, irrigation and other non-potable uses.

The separation of supplies would be easy in some cases: water could be pumped directly from large rivers for fighting fires in downstream areas of the larger cities. The separation would be less obvious where existing mains serve domestic and industrial users from a common source; but even here, when the existing systems need augmentation, we should consider maintaining those systems for potable use and building new systems for non-potable uses.

The important thing is that we undertake immediately a regional plan to serve adequate water to domestic, commercial and industrial users. The plan must incorporate the minimum objectives of serving water in sufficient quantities for drought conditions. This will allow us to sell the best water for potable uses and to use lower quality waters for creating lovelier river banks and even front lawns.

RALPH W. HORNE

1888-1981

Ralph W. Horne was born in Malden, Massachusetts, on July 25, 1888, and lived in that city during his entire life. He died suddenly on August 8, 1981, while vacationing in Vermont.

Mr. Horne received an SB degree in Civil Engineering from Massachusetts Institute of Technology in 1910. After experience as an instructor at Massachusetts Institute of Technology and designer with Metcalf & Eddy, he joined Fay, Spofford & Thorndike in 1915. Starting as an Assistant Engineer, he went on to become a partner in 1922, then presiding partner, and later director and president of Fay, Spofford & Thorndike, Inc. He was active in the company as a director through 1975, and as consultant through 1980.

In addition to management duties, he was always active in the planning, designing, and administration of water and sewer projects for many municipalities, mostly in New England. He has also been extremely generous with his time and talent in the direction of many charitable and other civic organizations, and in various engineering societies.

During his 65 years of activity in the water supply and sewage disposal field he was responsible for water supply systems in more than 25 cities and towns. He devised and developed many innovative methods and details which later became standard procedures.

Notable among his sewage disposal projects was a complete collection and treatment system for Cranston, Rhode Island, a city of 53,000 population at that time, and now a city of 75,000. Other sewer projects were for Bath, Maine; Gloucester, Saugus, Walpole, Brockton, Somerset, Billerica, Wareham, Webster, and Dudley, Massachusetts; Conway and Manchester, New Hampshire; and Bellows Falls and St. Albans, Vermont.

His water supply projects include those for Warwick and Narragansett, Rhode Island; Bath and Kennebunk, Maine; Georgetown, Adams, Sudbury, Sterling, Great Barrington, Winchendon, Peabody, and Pembroke, Massachusetts.

During the worst of the great depressions of the thirties, Mr. Horne was a Director of the Engineers Division of the Emergency Planning and Research Bureau, Inc., an activity sponsored and financed by the Engineering Societies of Boston and the Boston Society of Architects for the purpose of alleviating the widespread unemployment among engineers and architects. In this unpaid service, which he carried on in addition to his own consulting practice, he pesonally interviewed several hundred unemployed engineers and arranged for the employment of more than 300 of them in lines for which their training and experience had qualified them. His kindly, sympathetic attention to their serious situations and assistance to them at that time endeared him to all who realized the extent of this service.

His public service activities outside of engineering projects include terms of unpaid service in Malden for the Public Library, Davenport Memorial Foundation, the Redevelopment Authority, the Planning Board, and the City Council. He was a Trustee of Malden Savings Bank, Director and Vice President of First National Bank of Malden, and Trustee of Malden Hospital Corporation.

His memberships included the American Society of Civil Engineers (Member 1918, Fellow 1959), American Consulting Engineers Council, American Institute of Consulting Engineers, Boston Society of Civil Engineers (president 1932-1933, honorary member 1965), American Water Works Association, New England Water Works Association, American Academy of Environmental Engineers, New England Water Pollution Control Association, National Society of Professional Engineers, and Massachusetts Society of Professional Engineers. He served as an officer or on committees of most of these organizations. He was a registered professional engineer in several states.

Mr. Horne contributed numerous papers and articles to engineering publications, and received the Desmond Fitzgerald Award in 1944 for his presentation to the Boston Society of Civil Engineers of a paper on the Cranston project. This is the highest award of BSCE, and is made for a paper judged worthy of special commendation for its merit.

He received a Medal of Merit Award from the City of Malden in 1965. He was also elected Honorary Member of the Boston Society of Civil Engineers that year.

In 1964, a fund called the Ralph W. Horne Fund was created in his honor to provide the Boston Society of Civil Engineers with means for recognition each year of a member selected by the Board of Government for notable public service in an unpaid position.

Mr. Horne was a devoted family man. He was married in 1916 to Meta W. Cross, who died in 1979. He is survived by a daughter, Muriel Weldon, and by three grandchildren.

Ralph Horne will be sadly missed by a legion of friends and former associates. He was a superb member of the human race.

Prepared by Edward C. Keane

ARTHUR CASAGRANDE

1902-1981

After a long illness, Arthur Casagrande passed away on September 6, 1981.

Born in Haidenschaft, Old Austria, in 1902, he received his Civil Engineering degree in 1924, and Doctor of Engineering degree in 1933, both from the Technical University in Vienna, Austria. From 1924 to 1926, he was Assistant in Hydraulics at the Vienna Technical University; and from 1926 to 1932, he was Research Assistant with the U.S. Bureau of Public Roads, assigned to the Massachusetts Institute of Technology (MIT) where he assisted the late Professor Karl Terzaghi in his numerous research projects directed toward improving apparatus and techniques for soil testing. In those years, Arthur developed the liquid limit apparatus, the hydrometer test, the horizontal capillarity test, the consolidation apparatus, and the direct shear test equipment. Among his various research projects, he also conducted field investigations on frost action during a cooperative project of the U.S. Bureau of Public Roads and the New Hampshire State Highway Department. His criteria for frost susceptibility of soils, resulting from this project, were adopted by highway designers all over the world.

In 1929, when Terzaghi accepted a professorship at the Technical University in Vienna, Austria, he engaged Casagrande to install a soil mechanics laboratory for him. On leave of absence from the U.S. Bureau of Public Roads, Casagrande first visited several soil mechanics institutes in Germany and Sweden to collect useful information for the proposed laboratory in Vienna.

Casagrande returned in 1930 to MIT, where he built his first triaxial apparatus. During the period 1930 to 1932, he concentrated on research concerning shear strength and on consolidation tests on undisturbed clay. This resulted in his fundamental discovery that excess porewater stresses develop during shearing. In addition, he established a procedure for identifying the preconsolidation pressure of clays, and of evaluating time curves by means of semi-logarithmic plots.

In 1932, Casagrande accepted a lectureship at Harvard University, where he taught a two-semester course in soil mechanics and a course in foundation engineering. In the following year, he added a course in soil testing. In 1933, he received his Doctor of Science degree from the Technical University in Vienna. In 1934, Harvard made him an Assistant Professor. In 1935, he started a course on seepage and groundwater movement. In that year, he also handled his first assignment for the Corps of Engineers: Investigating the safety against liquefaction of the fine sand in the foundation of the Franklin Falls Dam in New Hampshire, and to advise on the control of seepage through the foundation of this dam.

In 1936, Casagrande conceived and organized the First International Conference on Soil Mechanics and Foundation Engineering, held at Harvard University, with Karl Terzaghi as President. In 1938, he was invited by the Corps of Engineers to become a member of the consulting board to investigate the failure at Fort Peck Dam. In 1939, the U.S. Army Engineer Waterways Experiment Station (WES) made a grant to Harvard and MIT for a comprehensive cooperative project in triaxial research, the results of which are contained in numerous progress reports that were published by WES in 1944.

In 1940, Harvard promoted Casagrande to Associate Professor. During the years 1942-1944, he trained about 400 officers of the U.S. Army Corps of Engineers, on the soil mechanics aspects of airfield construction. These officers were assigned to aviation engineer battalions in many parts of the world. It was in connection with these training courses that he developed his soil classification system, which was later adopted by the Corps and by the Bureau of Reclamation, with some modifications, as the Unified Classification System.

In 1946, he became Gordon McKay Professor of Soil Mechanics and Foundation Engineering; and in 1973, he retired from Harvard and became professor emeritus. In 1970, he joined with his brother Leo and nephew Dirk, to form a geotechnical consulting group under the name of Casagrande Consultants. In addition to his consulting activities, he remained active as an educator, lecturer and author. During his long career, he wrote or co-authored more than 100 professional papers.

Casagrande was an excellent teacher, devoted to his students, both in and out of the classroom. He followed with enthusiasm and pride the successful careers of many of his former students.

During his nearly five decades of consulting practice, he acted as consultant to numerous federal, state, municipal and private organizations on the foundations of a great variety of structures, on groundwater problems, and particularly on the design and construction of earth and rockfill dams and dikes. These projects took him to all parts of the world. Included among his many projects were: design of foundation for the Prudential Tower in Boston; a comprehensive study of the stability of the slopes of the Panama Canal and of possible sea level conversion of the canal; and design and construction of many of the world's largest hydro-power dams, including the Oahe Dam in South Dakota, the Manicouagan 3 Dam in Canada, the Tarbela Dam in Pakistan, and the Itaipu Dam in Brazil. He was occasionally called upon to investigate the cause of foundation problems or failures, as e.g. the failure of the Teton Dam in Idaho.

Casagrande was a Fellow or Honorary member of many professional societies, including: National Academy of Engineering; American Academy of Arts and Sciences; Geological Society of America; American Society of Civil Engineering; Boston Society of Civil Engineering; Mexican Soil Mechanics Society; Venzuelan Soil Mechancis Society; Japanese Soil Mechanics Society; and National Academy of Exact, Physical and Natural Sciences of Argentina. He was a Member of: International Society for Soil Mechanics and Foundation Engineering; U.S. Committee on Large Dams; American Geophysical Union, Highway Research Board; American Society for Engineering Education; Society of Harvard Engineers and Scientists; and Sigma Xi. In addition, he served as President of the Boston Society of Civil Enginers and of the International Society for Soil Mechanics and Foundation Engineering.

Casagrande received honorary doctor's degrees from his alma mater in Vienna, Austria, from the National University of Mexico, and from the University of Liège, Belgium.

He was the recipient of many awards and prizes, including the First Rankine Lecture (Institution of Civil Engineers, London), Terzaghi Award and Terzaghi Lecture (American Society of Civil Engineers), Decoration for Distinguished Civilian Service (awarded by the Secretary of the Army), Award of Merit presented by the American Institute of Consulting Engineers, the Moles Award, and the Order of the Rio Branco of Brazil. In 1978, the U.S. Army Engineer Waterways Experiment Station in Vicksburg, Mississippi, dedicated to him a new geotechnical research facility.

Words are not adequate to express the deep sense of loss experienced not only by Arthur Casagrande's family, but also by his countless friends and associates all over the world. We shall all miss his seemingly tireless devotion to solving difficult problems and his devotion to passing his knowledge on to others. But perhaps most of all, we will miss a man who genuinely cared about others, and a man who, even under the worst conditions, was able to maintain a wonderful sense of humor.

Prepared by Leo Casagrande and Dirk R. Casagrande

BERTRAM BERGER

1931-1982

Bertram Berger was born in Boston, Massachusetts on February 3, 1931 and died on April 3, 1982. He resided for most of his adult life in the town of Sharon, Massachusetts where he died suddenly while exercising.

Mr. Berger received his bachelor's degree in civil engineering from Northeastern University in 1954, was in military service for two years, and in 1956-1957 took graduate courses in transportation and soils at MIT. He started in 1957 with Fay, Spofford & Thorndike, Boston, as a junior engineer, acquired good experience in field and office on transportation and in other fields, and rose to project engineer level before long. His interest in and self-study of traffic engineering led to his being instrumental in forming a traffic engineering department at FS&T. He was responsible for acquiring and managing many major transportation projects, from planning through to construction, and in his career was involved in projects with a construction cost of over a billion dollars.

He became a company director in 1973 and vice president in 1974. At the time of his death he was a key figure for FS&T in the joint venture handling the Southwest Corridor project in Boston, and in the planning phase of a third vehicle tunnel under Boston Harbor.

Mr. Berger became an ASCE Member in 1965, has been active in several committees and chairman of the committee that arranged the national ASCE meeting in Boston in 1979. He was also active in the Boston Society of Civil Engineers, worked for the 1974 merger with the local section of ASCE and was president of the merged society in 1976-1977. He also held membership in the Massachusetts Society of Professional Engineers, the National Society of Professional Engineers, the Institute of Transportation Engineers, and the Society of American Military Engineers.

Mr. Berger was married shortly after graduation to S. Frances Forman and they had four daughters. He was devoted to his family, as well as to his profession, but made time also to serve on town committees and as a director of Temple Israel in Sharon, of which he was president in 1979-1980.

Bert Berger was always available to talk with younger people and counsel them. He was truly a *Man for All Seasons,* and he will be sorely missed, not only by his family and associates, but also by his host of friends in many areas.

Prepared by his associates in Fay, Spofford & Thorndike

ANNUAL REPORT OF THE BOARD OF GOVERNMENT, 1981-1982

To the Boston Society of Civil Engineers Section,
The American Society of Civil Engineers

Pursuant to the requirements of the Bylaws, the Board of Government presents its report for the year ending April 29, 1982.

A. MEMBERSHIP

The following is a statement of membership in the Section:

Honorary Members	3
Members	1044
Associate Members	326
Affiliates	37
Jr. Affiliates	1
TOTAL	1411
Student Chapters	9

Summary of Additions

New Members	18
New Associate Members	41
New Affiliate Members	1
New Jr. Affiliate Members	1
TOTAL	61

Summary of Losses

Deaths - Members	17
Honorary Members	1
Resignations - Members	18
Associate Members	6
Dropped - Members	56
Associate Members	27
TOTAL	125

Summary of Life Members

Prior years	199
Eligible 29 April 1982	12
TOTAL	211

ASCE Members assigned to BSCES

(not all subscribe)	2024

Honorary Membership is as follows:

John B. Babcock, III	elected	January 2, 1969
Albert G.H. Dietz	elected	January 19, 1981
John A. Volpe	elected	January 29, 1969

The following members have been lost through death:

Bertram Berger	April 3, 1982
John Campbell	May 19, 1981
David R. Campbell	January 16, 1982
Arthur Casagrande	September, 1981
Edward Drake	December 9, 1980
Walter C. Eberhard	1982
Herbert K. Fairbanks	December 13, 1980
Richard Gleason	January, 1981
Ralph W. Horne	August 10, 1981
Robert T. Jones	May 17, 1981
Frank M. McGowan	September 12, 1981
Murray B. McPherson	August 20, 1981
Wesley F. Restall	July 25, 1981
Miner R. Stackpole	1981
Arthur W. Vose	February 20, 1982
Julian White	December 7, 1981
Louis W. Wise	May 3, 1981
Henry I. Wyner	November 23, 1981

B. MEETINGS OF THE SECTION AND ITS TECHNICAL GROUPS:

The Section held meetings on the following dates:

September 23, 1981	Joint Meeting with the Computer and Hydraulics Groups and the Energy Committee
September 24, 1981	Monthly Luncheon; joint meeting with the Transportation Group
October 8, 1981	Joint Meeting with the Construction Group
October 28, 1981	Monthly Luncheon; joint meeting with the Employment Conditions Committee
November 12, 1981	Joint Meeting with the Geotechnical Group
December 3, 1981	Joint Meeting with the Environmental Group and Energy Committee
January 13, 1982	Joint Meeting with the Hydraulics Group
January 27, 1982	Monthly Luncheon; joint meeting with the Energy Committee
February 3, 1982	Joint Meeting with the Structual Group
March 10, 1982	Joint Meeting with the Transportation and Construction Groups
March 24, 1982	Monthly Luncheon; joint meeting with the Geotechnical Group

In addition to the above combined meetings with the Section, the Technical Groups held many other meetings and sponsored many lecture series. The details of the combined meetings with the Section, other meetings and lecture series are contained in the respective Annual Reports of the Technical Groups.

The details of the Monthly Luncheon meetings are contained in the Annual Report of the Monthly Luncheon Committee.

C. MEETINGS OF THE BOARD OF GOVERNMENT:

The Board of Government met on the following dates.

May 26, 1981	at the Engineers Club
June 15, 1981	at the Section's office
September 21, 1981	at the Section's office
October 9, 1981	at the Section's office
November 16, 1981	at the Section's office
December 21, 1981	at the Section's office
January 18, 1982	at the Section's office
February 16, 1982	at the Section's office
March 15, 1982	at the Section's office
March 22, 1982	Telephone Poll

For significant actions of the Board of Government, see Appendix A.

D. COMMITTEES:

Committees were appointed to deal with the activities and conduct of the Section. Except for the Nominating Committee (as provided in the Bylaws) these committees were under the general direction of the Board of Government, and reported to the Board of Government. The activities of the committees are described in the respective Annual Report of the Committees.

E. AWARDS:

The Board of Government voted a number of awards at its February 16th and March 15th meetings and by a telephone poll on March 22nd. See Appendix A, under these dates for a complete listing.

F. FUNDS:

The operating fund of the Section is called the Current Fund. The endowment of the Section is contained in the Permanent Fund. The principal of the Permanent Fund is invested, and the annual income so derived is either used to increase the principal, or at the discretion of the Board of Government, transferred to the Current Fund to help defray operating expenses. All entrance fees are income to the Permanent Fund.

In addition, there are special funds established by gifts or bequests and special funds established by the Board of Government. A listing of each of the special funds, together with a description of each, is given in Appendix B.

The Treasurer's Annual Report gives the status and the details of the transactions for all the funds.

Respectfully submitted,
Edward B. Kinner, President
Rubin M. Zallen, Secretary

APPENDIX A — Actions of the Board of Government

VOTED 5/26/81: 1. That up to $1,500 be expended for a complete audit of the Section's books covering October 1976 through March 1981, and to provide the Treasurer with professional financial advice through this fiscal year.

2. To establish an Ad Hoc Committee to investigate the establishment of an International Executive Service Corps in the Boston area, with Robert Snowber to serve as chairman.

3. To allot $675 from the Contingency Fund to sponsor three students to Northeastern University's Summer Institute for Minority High School Students.

VOTED 6/15/81: 4. To form a committee to consider the establishment of the office of Assistant Treasurer, to be chaired by Howard Simpson.

5. To proceed with the special Freeman edition of the BSCES Journal, the cost of which is to be paid from the Freeman Fund except for the first $5,000. The Section will contribute the first $5,000 from its regular Journal printing budget.

6. That, in accordance with the motion voted 11/17/80, the difference between $1,000 and the interest on $4,000 be budgeted to the Student Affairs Committee to fund special projects of the Student Chapters.

VOTED 9/21/81: 7. To establish the BSCES Technical Advisory Committees on the Building Code, to include sub-committees on Loads, Seismic Design and Foundations.

8. That the monies dispersed for the Fitzgerald and Morse Funds be referred to as awards rather than scholarships, and that a sum to be determined annually by the Board of Government be allocated from the interest earned by these Funds to present as awards to deserving students. $500 was voted from each Fund for this year's awards.

9. That the Section subsidize the Annual Meeting up to $1,500.

VOTED 10/19/81: 10. To accept the budget for fiscal 1981-1982 as prepared by the Treasurer.

11. To liquidate the so called "Invested Current Fund" to pay back loans made by the Invested Funds to the Current Fund.

12. To present to the members a proposal to increase the membership dues and, if voted by the membership, to apply this increase to the 1982 dues year.

VOTED 12/21/81: 13. That a portion of the assets of the Continuing Education Fund (approximately $5,700) be used to repay loans to the Current Fund that were made from the so called "non-invested" funds.

14. To establish for one year a Waterways, Port, Coastal and Ocean Technical Ad Hoc Committee, after which time the Board will consider reconstituting the committee as a Technical Group.

15. That President Kinner suggest to the State Hazardous Waste Facility Site Safety Council the establishment of a BSCES Advisory Committee for hazardous waste disposal.

16. To accept the final report of the Ad Hoc Commitee on Financial Responsibilities Within the Section, in particular: 1) That the Secretary no longer be required to approve

disbursements, 2) That the Executive Director be charged with approving payment vouchers prior to approval of the President, 3) That a Budget Committee be established, 4) That the annual Treasurer's Report be completed as soon as possible after the close of the fiscal year on September 30th and be submitted to the Board of Government at that time, 5) That an Interim Treasurer's Report for the current fiscal year as of March 31st be presented at the Annual Meeting in April along with the Treasurer's Annual Report for the previous fiscal year, 6) That the accountant prepare the IRS tax return, 7) That the position of Assistant Treasurer not be established, 8) That the Auditing Committee should conduct audits only annually at the close of each fiscal year, but should perform an additional audit when the Treasurer leaves office.

VOTED 1/18/82: 17. That, in accordance with a request by the Board of Government, and subsequent suggestions by the respective Technical Groups, a total of $3,824 be transferred from the Environmental, Geotechnical and Structural Groups Lecture Series Reserve Funds to pay back loans made to the Current Fund from the Invested Funds.

VOTED 2/16/82: 18. To present the Howe-Walker Student Awards to the following:

M.I.T.	Martin S. Liss
Merrimack College	Alessandro Martignetti
Northeastern University (Div. A)	Paul P. Livernois
Northeastern University (Div. B)	Joanna M. Kripp
Southeastern Mass.	Carol A. Rego
Tufts University	Jennifer Bryant
University of Lowell	Helene B. Demetroulakis
UMass	Joseph McDonough
Wentworth Institute	Theodore L. Scott
Worcester Polytechnic	Anni Autio

19. To present the 1982 Desmond Fitzgerald Award to Carol J. Lemb (Northeastern University).

20. To present the William P. Morse Award for 1982 to Leonard D. Albano (Tufts University).

21. To award a $1,000 Student Loan to each of the following:

George R. Samoil	University of Lowell
Brian A. Holmes	University of Lowell

VOTED 2/16/82: 22. To establish a Hazardous Waste Committee.

23. To establish a Student Grade of membership in the BSCES.

VOTED 3/15/82: 24. To present the Clemens Herschel Award to John R. Raymond for his paper published in Volume 67, No. 2 of the BSCES Journal.

25. To accept the Social Functions Committee's recommendation to discontinue the Annual Dance.

VOTED 3/22/82: 26. (via telephone poll of the Board of Government): To present the 1982 Ralph W. Horne Award to Frank E. Perkins.

VOTED 3/26/82: 27. That, upon the recommendation of the Investment Committee Section, funds be removed from the Boston Safe Deposit and Trust Company and that the Investment Committee, with Howard Simpson participating, meet to consider investment objectives and vehicles to meet those objectives. The Committee will submit their recommendations for action by the Board of Government.

APPENDIX B — Special Funds

1. *Invested Funds.*

The following funds are invested by the Section. The income from each fund is used to increase the principal of the fund, or is expended in a manner described for each fund below. All investments and expenditures are subject to the approval of the Board of Government.

LEROY G. BRACKETT FUND. This Fund was established on January 30, 1978 from a small bequest made by Donald F. Brackett. No formal recommendation for the use of the Fund has as yet been voted by the Board of Government.

THOMAS R. CAMP FUND. This Fund, a bequest of $10,000, was received January 15, 1971 from the Directors of Camp, Dresser & McKee, Inc. to establish the "Thomas R. Camp Fund", the income to be used to support an annual Thomas R. Camp lecture or lectures on outstanding recent developments or proposed or completed research in the sanitary engineering field. The income from the Fund, over and above that needed to support the annual lecture, should be added to the Fund, but could be used otherwise at the discretion of the Board of Government of the Boston Society of Civil Engineers Section of the American Society of Civil Engineers.

CONVENTION FUND. This Fund was established by the Board of Government on November 17, 1980 with an initial principal amount of $2,000 from the surplus realized by the 1979 ASCE Convention Committee. This Fund will be used for the planning of the next ASCE national convention in Boston in 1986.

DESMOND FITZGERALD FUND. The Desmond Fitzgerald Fund, established in 1910 by a bequest of $2,000 from the late Desmond Fitzgerald, a Past President and Honorary Member of the Society, provided that the income from this Fund "shall be used for charitable and educational purposes." On April 13, 1964, the Board of Government voted to establish a Boston Society of Civil Engineers Scholarship in memory of Desmond Fitzgerald to be funded by the income of this fund, and to be given to a student studying Civil Engineering at Northeastern University. On September 21, 1981, the Board of Government redesignated the gift to the student as an AWARD and stipulated that the amount of the award be determined annually.

JOHN R. FREEMAN FUND. In 1925 the late John R. Freeman, a Past President and Honorary Member of the Boston Society of Civil Engineers, made a gift to the Society of securities which were established as the "John R. Freeman Fund". The income from the Fund is to be particularly devoted to the encouragement of young engineers. Mr. Freeman suggested several uses, such as the payment of expenses for experiments and compilations to be reported before the Society; for underwriting meritorious books or publications pertaining to the hydraulic science or art; or a portion to be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to the Society; or establishing a traveling scholarship every third year open to members of the Society for visiting engineering works, a report of which would be presented to the Society.

ALEXIS H. FRENCH FUND. A bequest of $1,000 was received in 1931 from the late Alexis H. French, a Past President of BSCES. The income from the Fund is "to be devoted to the Library of the Society."

CLEMENS HERSCHEL FUND. This Fund was established in 1931 by a bequest of $1,000 from the late Clemens Herschel, a Past President and Honorary Member of BSCES. The income from the Fund "is to be used for the presentation of prizes for papers which have been particularly useful and commendable and worthy of grateful acknowledgement."

RALPH W. HORNE FUND. This Fund, a bequest of $3,000, was received June 29, 1964, from the Directors of Fay, Spofford & Thorndike, Inc., the income from which shall be devoted to a prize or certificate to be awarded annually to a BSCES member designated by the Board of Government to have been outstanding in unpaid public service in municipal, state or federal elective or appointed post; or in philanthropic activity in the public interest.

HOWE-WALKER FUND. A bequest of $1,000 was received December 2, 1933 from the late Edward W. Howe, a Past President of BSCE. No restrictions were placed upon the use of the money but it was decided at that time to keep the bequest intact in a separate fund, called the EDWARD W. HOWE FUND, and that the income be used for the benefit of the BSCE or its members.

A bequest of $1,000 was received in 1961 from Mary H. Walker, wife of Frank B. Walker, a former Past President of BSCE. No restrictions were placed upon the use of this money but it was decided at that time to keep the bequest intact in a separate fund, called the FRANK B. WALKER FUND, and that the income be used for the benefit of BSCE or its members.

On January 30, 1978, the Board of Government voted to combine the two funds into the HOWE-WALKER FUND, with income from this joint fund being used to provide prizes, called the HOWE-WALKER AWARDS, to members of student chapters. The awards are made annually at Student Night.

KARL R. KENNISON FUND. This Fund is derived from two irrevocable trusts established on behalf of BSCE by the late Karl R. Kennison, a Past President (1938-1939) and Honorary Member of BSCE. The trusts were established on August 29, 1960 and January 17, 1961. The trusts consisted of shares in the Massachusetts Fund, with the Massachusetts Company, Inc. as trustee. The total original market value of the trusts was $8,171.09. Three conditions of the trusts were that after Mr. Kennison's death: 1) that net income from the trusts shall be paid to BSCE for a Hydraulics Lecture Fund to be used for various public lectures on this subject, 2) the Board of Government could withdraw the principal of the trusts on written demand; and 3) the Board of Government may make changes in the use of the trust as it may determine are warranted.

Mr. Kennison died in April 1977. The principal was withdrawn from the trusts by the Board of Government in 1978 and placed in the Karl R. Kennison Fund, said fund being established for that purpose by the Board of Government.

LECTURES FUND. This Fund was established in December 1968 by the Board of Government by combining the Transportation Lectures Fund, the Structural Lectures Fund and the previous Lectures Fund into a single Lectures Fund. The purpose of the fund is to provide money for special lectures sponsored by the Society.

The Structural Lectures Fund was established in March 1954.

The Transportation Lectures Fund was established in 1961 by the Board of Government, with an initial appropriation of $125 from the Desmond Fitzgerald Fund and $125 from the William P. Morse Fund.

The original Lectures Fund was established by the Board of Government in 1967 to receive attendence fees and disburse expenses for a series of 14 lectures entitled the Use of Computers in Civil Engineering.

WILLIAM P. MORSE FUND. A bequest of $2,000 was received in 1949 from the late William P. Morse, a former member of BSCE. No restrictions were placed upon the use of the fund, but it was decided at that time to keep the bequest intact in a separate fund and that the income be used for the benefit of the Society and its members. On April 5, 1954, the Board of Government voted "to appropriate from the income of this fund a scholarship to be known as the Boston Society of Civil Engineers Scholarship in memory of William P. Morse, and that it be given to a civil engineering student at Tufts University."

ROGER GARDNER MEMORIAL FUND. This Fund was established at the request of the Student Affairs Committee. At the December 17, 1979 meeting of the Board of Government it was voted to present a certificate and a sum of money to be later determined to a deserving student. Funds for the certificate and cash award to be raised by solicitations made to BSCES members-at-large and area firms.

STUDENT AFFAIRS FUND. This Fund was established by the Board of Government on November 17, 1980 with an initial principal amount of $4,000 from the surplus realized by the 1979 ASCE Convention Committee. The annual income from this fund will be at the disposal of the Student Affairs Committee, with its use subject to the approval of the Board of Government.

EDMUND K. TURNER FUND. In 1916 the Society received a bequest of $1,000 from Edmumd K. Turner, a former member, the income of which is to be used for Library purposes.

2. *Non-Invested Funds.*

The following funds are under the control of the Treasurer. Any income that may be derived from the (short term) investment of these funds is credited to the Current Fund.

BORING DATA FUND. The Boring Data Fund was originally established in November 1958 by the Board of Government with an initial appropriation of $1,000 for the purpose of collating all of the boring data published in various BSCE Journals prior to that time, into one comprehensive edition. This report was published in 1961.

In 1968, the Board of Government appropriated $3,000 for publication of a supplement to the 1961 Report, and 46 consulting firms and contractors donated $6,355 to help pay the expenses of collecting and compiling the data. On May 21, 1969, the Board of Government voted to transfer $1,000 from the Frank B. Walker Fund to this fund, to insure continuation of the work. Further donations of $2,525 were obtained during the 1970-71 year. The supplement was published in four editions of the BSCE Journal from 1969 to 1971.

The remaining assets of the fund have been kept intact for the future publication of boring data.

CONTINUING EDUCATION FUND. The Continuing Education Fund is a special reserve fund established for accounting purposes to set aside profits from continuing education lecture series. This account is credited with amounts received as tuition and charged with honorariums and expenses paid.

GROUP LECTURE FUNDS. Established by vote of the Board of Government in 1976. Each lecture series organized by BSCES technical group is assigned a special fund for accounting purposes. 50% of the surplus from a lecture series is transferred to the Current Fund to help defray the Section operating expenses. The other 50% of the surplus is made available to the sponsoring technical group to defray expenses for other meetings, lecture series, technical and educational functions, subject to the approval of the Board of Government. Two years after completion of a lecture series, its fund is terminated and the remaining balance is transferred to the Current Fund.

STUDENT LOAN FUND. The Student Loan Fund was established in 1965-66. The assets of the fund are derived from donations solicited by the Student Affairs Committee from area firms.

The assets are used to make loans to deserving members of Student Chapters or clubs in the Section area, as approved by the Board of Government. The loans are interest free and repayable in four years following graduation.

MINUTES OF THE ANNUAL MEETING OF THE SECTION

Part I

April 26, 1982. Part I of the 134th Annual Meeting of the Boston Society of Civil Engineers (the eighth meeting of the Boston Society of Civil Engineers Section following the merger of the BSCE with the Massachusetts Section of ASCE) was held at the offices of Camp, Dresser & McKee, Inc. in Boston. The meeting was called to order at 3:00 p.m. by President Edward B. Kinner.

Executive Director Susan Albert distributed the Annual Report of the Board of Government.

Secretary Rubin Zallen asked that any member who has maintained historical records pertinent to the Society consider donating these records to the Section office.

Richard F. Murdock presented the Annual Report of the Treasurer as well as a brief mid-year report on the financial status of the Section.

Rodney P. Plourde presented the report of the Auditing Committee.

Secretary Rubin M. Zallen called for reports from the following Committees: Action Program, Advertising, Annual Meeting, Awards, Constitution and Bylaws, Thomas R. Camp Fund, Continuing Education, Employment Conditions, Energy, John R. Freeman Fund, Hazardous Waste, History and Heritage, Investment, Key Man, Lecture Series, Membership, Minority Affairs, Monthly Luncheon, Operations Manual, Program, Public Relations, Publications, Retired Engineers Service Program, Social Functions, Student Affairs, Technical Advisory Committees on the Building Code: Foundations, Loads and Seismic Design Sub-Committees, Waterways, Port Coastal and Ocean. Also for reports of the Technical Groups: Computer, Construction, Environmental, Geotechnical, Hydraulics, Structural and Transportation.

The reports of the Construction Technical Group, Loads Sub-Commitee and the Western Branch were not available for reading at this time. The report of the Nominating Committee was not read at this time as it had previously been distributed to the membership.

Secretary Zallen moved that the Committee and Technical Group reports be accepted and placed on file. It was seconded and so VOTED.

The results of the election of the Nominating Committee Members were announced. They are Steven L. Bernstein, Charles A. Rosselli and Robert A. Snowber.

Treasurer Murdock announced that at a Board of Government meeting directly preceeding this Annual Business Meeting it was VOTED to divest Boston Safe Deposit and Trust Company of all Section funds and to instruct the Investment Committee to consider alternative vehicles of investment.

Chairman of the Membership Committee, George Bollier, announced the names of Lawrence Feldman and Charles Fitts, who have applied for Affiliate Membership in the Section.

President Kinner presented Certificates of Appreciation to the retiring Technical Group Chairmen.

President Kinner concluded the meeting by presenting his retiring address, which is to be printed in the BSCES Journal.

Part II

April 29, 1982. Part II of the 1982 BSCE Section's Annual Meeting was held at the Museum of Science, Science Park in Boston. President Kinner reconvened the meeting at 8:20 p.m., following a tour of the Museum's West Wing, presentation in the Electric Theatre and dinner. President Kinner called upon Secretary Rubin Zallen to assist in the awarding of prizes and certificates to Life Members.

An award for a technical paper was presented as follows: (this was the only award for a technical paper voted this year by the Board of Government):

Clemens Herschel Award
Recipient: John R. Raymond of Pacific Northwest Laboratory
Paper: "Geohydrologic Aspects of Aquifer Thermal Energy Storage"

Secretary Zallen announced the awarding of a Certificate of Appreciation to Edward C. Keane for his many years as Editor of the BSCES Journal.

President Kinner presented Prof. Frank E. Perkins with the Ralph W. Horne Award for 1982.

Brief biographies of newly elected ASCE and BSCE Section Life Members were distributed, and President Kinner presented certificates to those BSCES Life Members present. New BSCES Life Members were as follows: Peter R. Bagarella, Albert J. Colacey, H. Lowell Crocker, John J. Cusack, Carmin E. Fulchino, David Giller, William J. Hallahan, Frederick B. Jackson, Joseph C. Lawler, Byron O. McCoy, Lorrin M. Pittendreigh and Norman P. Spofford.

Ronald C. Hirschfeld, District II member of ASCE's National Board of Direction presented ASCE Life Member certificates to those ASCE Life Members present. New ASCE Life Members were as follows: Bernard B. Berger, Richard J. Donovan, John G. Gill, Werner H. Gumpertz, William J. Hallahan, William J. Hentschel, Charles Y. Hitchcock, Jr., Myle J. Holley, Wilbar M. Hoxie, Robert F. Hudson, Anton Karpuk, Lloyd S. Lawrence, E. Boyd Livesay, Francis A. Obert and Nathaniel N. Wentworth, Jr.

President Kinner read the names of members who died during 1981-1982: David R. Campbell, John S. Campbell, Edward Drake, Walter C. Eberhard, Herbert K. Fairbanks, Richard Gleason, Robert T. Jones, Frank M. McGowan, Murray B. McPherson, Wesley F. Restall, Miner R. Stackpole, Arthur W. Vose, Julian White, Louis W. Wise and Henry I. Wyner. Three Past Presidents were also lost through death this past year: Arthur Casagrande and Ralph W. Horne, Past Presidents of the BSCE, and Bertram Berger, Past President of the BSCE Section.

President Kinner recognized Past President Howard Simpson, who is leaving the Board of Government this year, for his many contributions to the Section. President Kinner also introduced S. Russell Stearns, Zone I, District II's candidate for the office of ASCE President-Elect.

President Kinner then turned over the gavel to incoming President Stanley C. Rossier, who presented a plaque and past president's pin to retiring President Kinner commemorating his year as president. President Rossier made a few brief remarks and introduced the 1982-1983 officers and directors: Vice Presidents Richard J. Scranton and John P. Sullivan, Secretary Rodney P. Plourde, Treasurer Richard F. Murdock and Directors Judith Nitsch, Warren H. Ringer, David E. Thompson and Rubin M. Zallen.

President Rossier then introduced the guest speaker, Dr. Barbara Baum, who commented on her year at the State Department in Washington, D.C. as a Science, Engineering and Diplomacy Fellow.

One hundred and ninety-one members and guests attended the dinner and evening meeting.

ANNUAL REPORT OF THE TREASURER

For the Fiscal Year October 1, 1980 to September 30, 1981

FISCAL STANDING

The Fiscal Standing of the Section is summarized in the four tables which accompany this report.

Table I - Condensed Statement of Condition
Table II - Condensed Statement of Income and Expenditures
Table III - Detailed Statement of Income and Expenditures
Table IV - Portfolio of Investment and Projected Yield

SECTION INVESTMENTS

The Boston Safe Deposit and Trust Company continues as custodian of our portfolio of securities and has furnished us with an annual summary account. The Custodian continues to make portfolio changes and reports quarterly on the portfolio performance. During this year the Custodian was authorized to send all income from the portfolio to Section headquarters for use by the Secion.

SECTION BANK DEPOSITS

All non-invested cash is deposited into a Suffolk Franklin NOW Account and a Putnam Daily Dividend Trust. Both are interest bearing accounts. The fiscal record was:

	Debit	*Credit*	*Balance*
Suffolk Franklin NOW Account			
Balance 10/1/80			$10,174.00
Deposits 10/1/80-9/30/81		$145,108.00	
Interest		1,322.00	
Checks Drawn	$146,485.00		
Totals (Suffolk)	$146,485.00	$146,430.00	$10,119.00
Putnam Daily Dividend Trust			
Balance 6/23/81			$20,000.00
Interest		$ 936.00	
Totals (Putnam)		$ 936.00	$20,936.00

PERMANENT FUND

The Permanent Fund receives its prorated portion of investment income and all entrance fees for the local Section membership. A prorated portion of custodial service charge is debited.

	Debit	*Credit*	*Balance*
Book Value 10/1/80			$115,819.00
Custodian Service	$ 1,134.00		
Interest, Dividends		$12,724.00	
Transactions			
Transfer to Current Fund	12,724.00		
Totals	$13,858.00	$12,724.00	$114,685.00

TECHNICAL GROUP LECTURE SERIES FUNDS 1981

Geotechnical Group - Groundwater Hydrology

Beginning Balance			$ 3,794
Income	$43,716		
Expenses	$19,371		
	$24,345		
50% available for approved expenditures		$12,172	
Expenses 1980-1981		$ 1,093	
Subtotal		$11,079	
Available 1981-1982			$14,874

Hydraulics Group - Small Scale Hydro Power

Beginning Balance		$ 0
Income	$14,585	
Expenses	$15,492	
Deficit	$ (907)	
Available 1981-1982		$ (907)

Environmental Group - Camp Lecture

Beginning Balance		$ 1,224
Income	$ 362	
Expenses	$ 370	
Deficit	$ (8)	
Available 1981-1982		$ 1,216

Structural Group - Building Cladding

Beginning Balance		$ 2,093
Income	$ 30	
Expenses	$ 335	
Deficit	$ (305)	
Available 1981-1982		$ 1,788

TECHNICAL GROUP FISCAL OPERATIONS 1980-1981

	Income	*Expense*	*Surplus*	*Deficit*
Computer	$ 855	$ 171	$ 684	
Construction	1,601	1,588	13	
Environmental	363	371		8
Geotechnical	3,261	4,355		1,094
Hydraulics	152	467		315
Structural	0	1,329		1,329
Transportation	0	0		0
	$6,232	$8,281	$ 697	$2,746

Respectfully submitted,
Richard F. Murdock, Treasurer

TABLE I

CONDENSED STATEMENT OF CONDITION
Assets, Liabilities and Funds

ASSETS	BOOK VALUE		MARKET VALUE	
	9-30-81	9-30-80	9-30-81	9-30-80
Mutual Bank Now Account	$ 10,175	$ 10,136	$ 10,175	$ 10,136
Putnam Daily Trust	20,649		20,649	
Boston Safe Deposit:				
Bonds	114,681	106,807	88,369	86,661
Stocks	146,283	108,980	172,186	142,493
Principal cash and short term investments	31,054	65,749	31,054	65,749
Income cash*	3,682	3,318	3,682	3,318
Total, Boston Safe Deposit	$295,700	$284,854	$295,291	$298,221
TOTAL ASSETS	$326,524	$294,990	$326,115	$308,357
TOTAL FUNDS LIABILITIES (Schedule 1)	$331,430	$303,232	$331,021	$316,599
NET WORTH (DEFICIT)	$ (4,906)	$ (8,242)	$ (4,906)	$ (8,242)
TOTAL FUNDS AND NET WORTH	$326,524	$294,990	$326,115	$308,357

SCHEDULE 1 - FUNDS LIABILITIES, 9-30-81

	BOOK VALUE		MARKET VALUE	
	9-30-81	9-30-80	9-30-81	9-30-80
Camp Fund	$ 18,513	$ 17,136	$ 18,487	$ 17,950
Permanent Fund	114,685	115,819	114,530	121,135
Freeman Fund	91,653	85,256	91,525	89,381
Turner Fund	5,260	4,871	5,253	5,103
Fitzgerald Fund	7,813	7,406	7,802	7,767
French Fund	5,198	4,819	5,191	5,047
Herschel Fund	3,286	3,051	3,281	3,197
Howe Fund	5,604	5,188	5,596	5,440
Morse Fund	7,140	6,797	7,130	7,129
Walker Fund	2,450	2,258	2,447	2,368
Horne Fund	6,821	6,598	6,811	6,911
Lecture Fund	6,349	6,170	6,340	6,496
Bracket Fund	363	361	362	378
Kennison Fund	11,967	11,097	11,950	11,624
Invested Current Fund	8,570	7,947	8,558	8,215
Roger Gardner Fund	28	80	28	80
Total Liabilities to Invested Funds	$295,700	$284,854	$295,291	$298,221
Continuing Education Fund	9,419	7,762	9,419	7,762
Boring Data Fund	1,596	1,596	1,596	1,596
Student Loan Fund	1,744	1,909	1,744	1,909
Group Lectures	16,971	7,111	16,971	7,111
Convention Fund	2,000		2,000	
Student Affairs Fund	4,000		4,000	
Total Non-invested Funds	$ 35,730	$ 18,378	$ 35,730	$ 18,378
TOTAL FUNDS LIABILITIES (To Table I)	$331,430	$303,232	$331,021	$316,599

TABLE II
CONDENSED STATEMENT OF INCOME AND EXPENDITURES
FISCAL YEAR 10-1-80 to 9-30-81

Fund Name	*Book Value 10-1-80*	*Interest Dividends Transactions*	*Receipts*	*Loan To Current Fund*	*Transfers To Current Fund*	*Expen-ditures*	*Custodian Charges*	*Book Value 9-30-81*
Permanent	$115,819	$12,724	$ 0	$ 0	$12,724	$ 0	$1,134	$114,685
Freeman	85,256	9,600		1,917		430	856	91,653
Turner	4,871	548		110		0	49	5,260
Fitzgerald	7,406	834		153		200	74	7,813
French	4,819	542		115		0	48	5,198
Herschel	3,051	342		76		0	31	3,286
Howe	5,188	583		115		0	52	5,604
Morse	6,797	764		153		200	68	7,140
Walker	2,258	253		38		0	23	2,450
Horne	6,598	742		153		300	66	6,821
Lectures	6,170	694		153		300	62	6,349
Camp	17,136	1,931		382		0	172	18,513
Bracket	361	3		0		0	1	363
Kennison	11,097	1,249		268		0	111	11,967
Investment - current	7,947	894		191		0	80	8,570
Roger Gardner	80	1		0		53	0	28
Total	$284,854	$31,704	$ 0	$3,824	$12,724	$1,483	$2,827	$295,700

DISTRIBUTION OF NON-INVESTED FUNDS, FISCAL YEAR 10-1-80 to 9-30-81

Fund Name	*Book Value 10-1-80*	*Interest Dividends Transactions*	*Receipts*	*Loan To Current Fund*	*Transfers To Current Fund*	*Expen-ditures*	*Custodian Charges*	*Book Value 9-30-81*
Continuing Education Fund	$ 7,762	$	$ 5,155	$	$ 0	$ 3,498	$	$ 9,419
Boring Data Fund	1,596		0		0	0		1,596
Student Loan Fund	1,909		1,895		0	2,060		1,744
Group Lecture Series*	7,111		58,693		13,265	35,568		16,971*
Convention Fund	0		2,000		0	0		2,000
Student Affairs Fund	0		4,000		0	0		4,000
Total	$18,378	$ 0	$71,743	$ 0	$13,265	$41,126	$ 0	$35,730

*Geotechnical	14,874
Structural	1,788
Hydraulics	(907)
Environmental	1,216
	16,971

TABLE III
DETAILED STATEMENT OF INCOME AND EXPENDITURES
Fiscal Year 10-1-80 to 9-30-81

		Expenditures	*Income*
TOTAL INCOME	(Schedule 2)		$147,081
TRANSFERS	(Schedule 3)	$ 20,000	
OFFICE AND ADMINISTRATIVE	(Schedule 3)	36,603	
PRINTING AND ADVERTISING	(Schedule 3)	19,305	
SOCIAL	(Schedule 3)	10,630	
SOCIETY BUSINESS	(Schedule 4)	1,356	
TECHNICAL GROUPS	(Schedule 4)	8,281	
LECTURE SERIES	(Schedule 4)	40,927	
STUDENT AFFAIRS	(Schedule 4)	2,690	
COMMITTEES	(Schedule 5)	2,937	
GENERAL	(Schedule 5)	2,285	
FUNDS	(Schedule 5)	1,483	
TOTAL		$146,497	$147,081

SCHEDULE 2 - INCOME, 10-1-80 to 9-30-81

		TOTAL
Dues		$ 22,362
Allotment		3,063
ACEC/NE Reimbursement		13,383
Bank interest - NOW account		1,323
Dividend income - Putnam Fund		649
Entrance fees		376
Contributions		1,611
Transfers from investments		18,031
Office and Administrative:		
Postage	$ 3	
Staff insurance	27	30
Printing and Advertising:		
Advertising	2,095	
Publication sales	2,659	4,754
Social:		
Annual meetings	4,060	
Clambake	4,786	8,846
Technical Groups:		
Computer	855	
Construction	1,601	
Environmental	363	
Geotechnical	3,261	
Hydraulics	152	6,232
Lecture Series:		
Continuing education	5,155	
Geotechnical	43,716	
Structural	30	
Hydraulics	14,585	63,486

SCHEDULE 2 (Cont.)

Student Affairs:		
Loans	1,895	
Student night	275	2,170
Committees:		
Monthly luncheon	42	
Miscellaneous	150	192
General:		
General contingency	390	
M E C	121	
Miscellaneous	62	573
TOTAL		$147,081

SCHEDULE 3 - TRANSFERS, OFFICE AND ADMINISTRATIVE, PRINTING AND ADVERTISING, AND SOCIAL EXPENDITURES, Fiscal Year 10-1-80 TO 9-30-81

TRANSFERS TO INVESTMENTS	$20,000
OFFICE AND ADMINISTRATIVE:	
Salaries	$16,048
Secretarial	1,240
Taxes	8,920
Personnel annuity	1,160
Insurance	129
Rent	1,862
Electricity charge from ACECNE	43
Telephone	646
Postage	2,680
Office services	443
Office supplies	1,035
Petty cash	86
Staff insurance	561
Office copier	1,750
TOTAL	$36,603
PRINTING AND ADVERTISING:	
Journal	$12,145
Newsletter	2,470
Monthly notices	4,041
Advertising	18
Publication sales	83
General printing	568
TOTAL	$19,305
SOCIAL:	
Annual meeting	$ 6,031
Dinner dance	250
Clambake	4,055
Awards	294
TOTAL	$10,630

SCHEDULE 4 - SOCIETY BUSINESS, TECHNICAL GROUPS, LECTURE SERIES, AND STUDENT AFFAIRS EXPENDITURES, Fiscal Year 10-1-80 TO 9-30-81

SOCIETY BUSINESS:	
Local society	$ 100
New England Council	241
Western Branch	1,000
ASCE conference	15
TOTAL	$ 1,356
TECHNICAL GROUPS:	
Computer	$ 171
Construction	1,589
Environmental	370
Geotechnical	4,355
Hydraulics	467
Structural	1,329
TOTAL	$ 8,281
LECTURE SERIES:	
Camp lecture series	$ 1,231
Continuing education	3,498
Geotechnical	19,371
Structural	335
Hydraulics	15,492
MIT - CAES	1,000
TOTAL	$40,927
STUDENT AFFAIRS:	
Summer institute	$ 630
Loans	2,060
TOTAL	$ 2,690

SCHEDULE 5 - COMMITTTEES, GENERAL AND FUNDS EXPENDITURES, Fiscal Year 10-1-80 TO 9-30-81

COMMITTEES:	
Legislative affairs	$ 2,160
Membership	261
Monthly luncheon	155
Energy	206
Public relations	155
TOTAL	$ 2,937
GENERAL:	
General contingency	$ 2,185
M E C	100
TOTAL	$ 2,285
FUNDS:	
Freeman fund	$ 430
Lecture fund	300
Horne fund	300
Morse fund	200
Fitzgerald fund	200
Roger Gardner fund	53
TOTAL	$ 1,483

ANNUAL REPORTS OF COMMITTEES

Report of Action Program - Professional Practice Committee, 1981-1982

The committeee has been active in several areas of concern to the profession this past year; we have investigated and made recommendations to the Board of Government relative to the issue of interaction between the Society and the (Massachusetts) Hazardous Waste Facility Site Safety Council. The Committee also complied with requests from the Design Professional Government Affairs Council to make a recommendation for a candidate to serve on the Designer Selection Board, and submitted nominations for the Boston Zoning Commission and Board of Appeals.

The new year will see increased activity in areas related to changes in State legislation due to reduced funding of commissions and other agencies, such as to affect the engineering profession.

Respectively submitted,
Robert H. Stewart, Chairman

Report of Advertising Committee, 1981-1982

The advertising rates were reviewed. With publication of the Journal reduced from four issues per year to two issues per year, the advertising rates will remain unchanged.

As of March 1982, letters were being prepared for mailing to approximately 120 potential new advertisers, mainly consulting firms in the Boston area. The response to the mailing will be evaluated and follow-up action to increase advertising will be determined.

Respectfully submitted,
John P. Dugan, Jr., Chairman

Report of Auditing Committee, 1981-82

An audit of the Section's financial records was conducted by the Auditing Committee for the fiscal year, October 1, 1981 through September 30, 1982. The audit included discussions with the Section's Treasurer, Secretary and Executive Director as to accounting procedures of the Section, followed by detailed review of the Secretary's ledger (receipts) and the Section's checkbook (disbursements). The Secretary's ledger was checked against the bank statements for consistency of the ledger entries of deposits, and found to be in order. The mathematics of the ledger entries was also checked. The Section's checkbook was checked against bank statements for consistency of deposits, interest, and checks written, and was also found to be in order and balanced. The Auditing Committee also compared the Treasurer's list of securities and investments with the Investment Custodian's list, and found them to be in agreement.

Respectfully submitted,
Rodney P. Plourde, Warren H. Ringer

Annual Report of Awards Committee, 1981-1982

The Committee reviewed applicable *Journal* articles for the purpose of establishing the annual Fitzgerald, Herschel, and Technical Group Awards. The following award is recommended:

Clemens Herschel Award:
John R. Raymond, "Geohydrologic Aspects of Aquifer Thermal Energy Storage"

The Committee also considered nominations for the Ralph W. Horne Award, for recognition of Section members who have been outstanding in either unpaid public service or municipal, state, or federally elected or appointed posts or in philanthropic activities in the public service. The Committee recommends Dr. Frank E. Perkins for the Horne Award on the basis of his commendable public service. Documents outlining Dr. Perkins' accomplishments are on file in the Section Office.

Respectfully submitted,
Richard J. Scranton, Lee Marc G. Wolman, Glenn Orenstein
Donald W. Nickerson, Gerald C. Potamis, Asaf A. Qazilbash
Varoujan Hagopian, Kenneth W. Wiesner, Robert A. Snowber
Judith Nitsch, Chairman

Report of Thomas R. Camp Fund Committee, 1981-1982

The 1982 Thomas R. Camp Lecture was held on April 14, 1982 at Northeastern University, Boston. Dr. Walter J. Weber, Professor, University of Michigan gave a presentation entitled "Adsorption in Water and Wastewater Treatment, Overview and Perspectives".

The financial status of the fund is set forth in the Report of the Treasurer.

Respectfully submitted,
Gerald C. Potamis, Chairman

Report of Constitution and Bylaws Committee, 1981-1982

The Constitution and Bylaws Committee prepared or reviewed proposed amendments to the Constitution and Bylaws in three areas:

1. The IRS has proposed a constitution change to justify our maintenance of a tax free status.

2. The new student member grade required changes in both the Constitution and Bylaws.

3. The Membership Committee proposed simplification of Bylaws for Affiliate and Junior Affiliate Membership grades. These were reviewed by the Committee.

Saul Namyet

Report of Continuing Education Committee, 1981-1982

The Continuing Education Committee presented a series of eleven lectures in the fall of 1981 and the spring of 1982 to assist practicing engineers preparing for the state registration examination. Total enrollment was 51. Based on the response of questionnaires that have been received from students taking the state examinations over the last few years, all class lecturers are currently in the process of revising and updating their notes. It is anticipated that the revised notes will be available for student use and nationwide sale by the fall of 1982.

Respectfully submitted,
Ronald E. Sharpin, Chairman

Report of Employment Conditions Committee, 1981-1982

The Committee membership for this year was as follows:

Kevin K. Egan, Chairman
James P. Troupes

The committee invited Mr. Robert Barton of the American Society of Civil Engineers' Supply and Demand Committee to speak at the November luncheon, but the meeting was cancelled.

The committee has developed a questionnaire, scheduled to be mailed this spring, that will help it to develop a guide for employment conditions for local use.

Respectfully submitted,
Kevin K. Egan, Chairman

Report of Energy Committee, 1981-1982

Members of the Committee during 1981-1982 were:

A. S. Lucks, Chairman
R. P. Barry
T. Keller
D. W. Miles
R. H. Stewart
P. K. Taylor

The Committee cosponsored five meetings during the fall of 1981 and the spring of 1982. These meetings were as follows:

September 23, 1981 — "A Novel Approach to the Harnessing of Tidal Energy," presented by A. M. Gorlov (cosponsored with the Hydraulic Group).

November 4, 1981 — "Energy Conservation Systems at New England Telephone" presented by A. H. Boyle (cosponsored with the Computer Group).

December 3, 1981 — "Waste to Energy - Fact or Speculation," presented by W. R. Niessen (cosponsored with the Environmental Group).

January 27, 1982 — "The National Energy Policy," presented by M. G. Tyson (Monthly Luncheon Series).

February 25, 1982 — "Geotechnical Aspects of Earth-Sheltered Building Design and Construction," presented by Dr. Raymond Sterling (cosponsored with the Geotechnical Group).

The Committee appreciates the support received from the Technical Groups in bringing these energy issues before the Society.

No membership comments were received on the Draft Energy Policy Statement that was published in the November 1980 Newsletter.

Respectfully submitted,
A. S. Lucks, Chairman

Report of John R. Freeman Fund Committee, 1981-1982

The year was an active one for the committee.

It sponsored the special issue of the Journal, Vol. 67, Number 4, Summer 1981 - "Boston's Charles River Basin - An Engineering Landmark." This book was available in time for the November 5, 1981 ceremony at the Science Museum at which the basin was dedicated as a National Historic Civil Engineering Landmark.

It awarded the second Freeman Hydraulics prize to Gerhard H. Jirka, Associate Professor in the School of Civil and Environmental Engineering at Cornell University, for his paper "Multiport Diffusers for Heat Disposal - A Summary." Professor Jirka is scheduled to present his paper, as the Eleventh Freeman Memorial Lecture, on April 21, 1982 at M.I.T. at a joint meeting of the Hydraulics Group and the M.I.T. Student Chapter of ASCE.

The above activities required disbursements from the Freeman Fund in excess of $11,000. The Committee plans to curtail expenditures until the fund has been restored, through earnings, to its original value, approximately inflated.

The Committeee was saddened by the death of David R. Campbell, who had served as a member since 1968.

Respectfully submitted,
THE JOHN R. FREEMAN FUND COMMITTEE
Harry L. Kinsel, Lawrence C. Neale, Donald R.F. Harleman
Lee Marc G. Wolman, Chairman

Report of Geotechnical Advisory Committee, 1981-1982

This Committee was established by BSCE Section by vote of the Board of Government on September 21, 1981. It succeeds the Soils Advisory Committee that reported to the former Massachusetts Building Code Commission, a State commission that was eliminated during 1981 due to budget constraints.

The purpose of the Committee is to provide a forum wherein changes to the geotechnical provisions of the Massachusetts Building Code can be formulated by a technically competent body. Recommendations will be published for consideration by the profession and submitted to the appropriate state regulatory agency.

Committee members need not be members of BSCE Section or ASCE, except that a majority, including the Chairman, must be members of BSCE Section. The Committee members are:

Steve J. Poulos	Chairman
Edmund G. Johnson	Vice Chairman
Paul Donahue	Secretary
Michael W. C. Emerson, Peter Riordan	Members
William R. Langrill, Richard M. Simon	Members
Asaf Qazilbash, Peter K. Taylor	Members

Currently several revisions are being considered, the most significant of which is a major revision of Table 720. Those interested in further details are welcome to contact any of the Committee members.

Respectfully submitted,
Steve J. Poulos, Chairman

Report of Hazardous Waste Committee, 1981-1982

On February 16, 1982 the Board of Government approved the formation of a Hazardous Waste Committee. The Action Program/Professional Practice Committee had recommended the establishment of such a committee and the membership of the Section also indicated a strong desire to form a Hazardous Waste Committee.

The following interim goals were established, pending completion of committee organization and report to the Board of Government.

1. Jointly sponsor with Technical Groups, meetings relating to hazardous waste.
2. Be a point of contact for hazardous waste issues between BSCE Section, ASCE headquarters, and other professional and public organizations.

The committee will be part of the Professional and Section Affairs Division of the Section.

On March 30, 1982 the Committee elected the following individuals to serve as members of its Executive Committee for 1982-1983:

Robert C. Faro
Brendan M. Harley
Thomas L. Neff
John L. Splendore
Wesley Stimpson

The Executive Committee met on April 13, 1982 and elected Brendan Harley Chairman.

The Hazardous Waste Committee has been asked to review draft regulations for siting hazardous waste management facilities in Massachusetts and to make recommendations for a qualified hydrogeologist to serve on the Massachusetts Hazardous Waste Facility Site Safety Council.

Respectfully submitted,
Gerald Potamis, Chairman

Report of History and Heritage Committeee, 1981-1982

On November 5, 1981, the Charles River Basin was dedicated as a National Historic Civil Engineering Landmark, the eighth in Massachusetts. The ceremonies took place at the Museum of Science where the plaque was unveiled by Pres. James R. Sims of ASCE. The affair was notable for the fine cooperation and participation of the MDC, the Museum of Science and other interested groups. Members of the Freeman family were present as we honored John R. Freeman.

On December 14, 1981 we were officially notified that the Borden Base Line had been designated as a National Historic Civil Engineering Landmark. The Western Branch is working with the Committeee on arrangements for the dedication.

Mr. Potamis is working on the Canton Viaduct for national or Massachusetts designation.

Mr. Battles is working on the early materials testing at the Watertown Arsenal for national designation.

Mr. Kraemer is working on the Brockton Railroad Viaduct and Bridges for Massachusetts, or possibly national, recognition.

Mr. Cahill and Mr. Holly are researching civil engineering developments in connection with power generation and the industrial revolution.

Mr. Holly is again serving as a member of the national ASCE Committee on the History and Heritage of American Civil Engineering.

Richard Battles, Jim Cahill, Steven R. Kraemer, Gerald C. Potamis
H. Hobart Holly, Chairman

Report of Investment Committee, 1981-1982

The Committee met in September 1981 with the Custodian of the Section's funds, Boston Safe Deposit and Trust Company, to review the Section's holdings. At a subsequent meeting in January 1982 it was decided to proceed with an extensive review of the financial performance of the custodian in comparison with other mutual funds and closed-end investment vehicles. Based on a comprehensive review of available investment performance records, it was agreed by the Board of Government in April 1982 to terminate the Section's custodial agreement with the Boston Safe Deposit Company, liquidate the portfolio, and consider alternative investments in mutual funds and other closed-end investment vehicles.

Respectfully submitted,
Richard F. Murdock, Chairman

Report of Key Man Committee, 1981-1982

The Key Man Committee acts as a line of rapid communication between the society and its members in local engineering firms or agencies. Its primary purpose is to serve as a means of alerting or reminding members of coming meetings or events of the society.

In 1981 the key man list was revised and the number of firms or agencies represented on the committee was increased from 51 to 79. The committee was activiated for social events, as well as for some noon luncheon meetings and dinner meetings.

Respectfully submitted,
Wayne E. Kilker, Chairman

Report of Lecture Series Committee, 1981-1982

The Lectures Series Committee met several times during the year to coordinate the planning, scheduling, and execution of lecture series.

The status of the various series is as follows:

Structural Group. Series on building cladding: completed in winter of 1982 with revenue exceeding cost. Proposed series (topic to be selected) tentatively scheduled for Fall of 1983.

Geotechnical Group. Series on engineering geology: scheduled for Fall of 1982. Series in conjunction with International Society of Soil Mechanics and Foundation Engineers: scheduled for Summer of 1983.

Computer Group. Series on computer aided design: tentatively scheduled for Spring of 1983.

Transportation Group. Seminar on Stress Management: being conducted during Spring of 1982.

Hydraulics Group. Series (topics to be selected): tentatively scheduled for Spring of 1983.

Environmental Group. Nothing planned.

Construction Group. Nothing planned.

Waterways, Port, Coastal and Ocean Committee. Series on Coastal Engineering: to be scheduled.

Respectfully submitted,
Richard J. Scranton, Chairman

Report of Membership Committee, 1981-1982

The Membership Committee this year consisted of Thomas Carabine, James Errico, Paul Ozarowski, Vernon LeBlanc, and George Bollier, Chairman.

The Committee undertook five projects during 1981-1982 as follows:

1. Continuation of sign-up sheets at Technical Group meetings.
2. Mailing BSCES/ASCE information to college seniors (an annual project).
3. Streamlining Affiliate/Junior Affiliate membership process.
4. Solicitation of assistance from members of Key Man Committee.
5. Coordination with ASCE national membership campaign.

The Committee also assisted in the processing of Affiliate/Junior Affiliate membership applications and coordinated with the Student Affairs Committee on recommendations for establishing a Student Member grade for BSCES.

Sign-up sheets were used again this year at each of the Technical Group Meetings to identify attendees who were not members of BSCES. Each non-member was then contacted regarding membership.

We are preparing a mailing of ASCE membership applications, ASCE and BSCES brochures, and an invitation to join BSCES, to civil engineering seniors at area colleges. This mailing should be out in April.

The Committee has developed recommendations for streamlining the Affiliate/Junior Affiliate membership process to reduce the inordinate amount of time it currently takes to process these applications, but any changes in the process will require a constitutional change. The recommendations are therefore being reviewed with Judy Nitsch, Chairman of the Administrative Division, and Saul Namyet, Chairman of the Constitution and Bylaws Committee.

Each of the members of the Key Man Committee was provided with packets containing an introductory letter, a Why Join? brochure, and a BSCES membership application to distribute to persons who they felt were potential candidates for BSCES membership. In addition, each was provided with a notice to post at his or her firm informing fellow employees that anyone desiring BSCES membership information should contact either the Key Man Committee member or the Chairman of the Membership Committee.

The Committee has coordinated its efforts with the ASCE National Membership drive. The Committee distributed prospects cards both through the Technical Group Meetings and through the BSCES News. Each person whose name is sent to ASCE receives membership information from ASCE and from BSCES.

Respectfully submitted,
George H. Bollier, Chairman

Report of Minority Affairs Committee, 1981-1982

The Committee membership for this year was as follows:

Jack D. Bryant, Chairman
Jacques A. Borges

The Committee was active in researching existing programs in the Boston area for minority persons who are interested in an engineering career, or programs which provide contacts with practicing engineers to show what engineers do; and in identifying opportunities in education toward becoming a professional engineer.

The Committee is preparing a draft statement of goals and recommendations for the attainment of these objectives.

The chairman has been involved in miscellaneous activities pertaining to training programs for minorities, and served as a guest speaker at the Roxbury Community College during Engineers Week in 1982 on "Minorites in Engineering."

Respectfully submitted,
Jack D. Bryant, Chairman

Report of Monthly Luncheon Series Committee, 1981-1982

This year a series of luncheon meetings was continued to provide a monthly function where the membersip can meet and discuss timely professional topics.

The luncheon meetings were held at the Great Hall, Quincy Market and the September meeting attracted over 130 persons. The meetings held were:

Thursday, September 24, 1981; Speaker - Mr. William Hellman, of Baltimore, Transportation Coordinator for the city. Topic - Construction of the I-95 Fort McHenry Tunnel.

Wednesday, October 28, 1981; Speaker - Mr. Robert Barton, P. E., Sales Engineer, Rosenfeld Concrete; Topic - Supply and Demand of Civil Engineers.

Wednesday, January 27, 1982; Speaker - Mr. Mitchell Tyson, Legislative Assistant to Senator Paul Tsongas; Topic - The National Energy Policy.

Wednesday, March 24, 1982; Speaker - David Weiner, Director of Engineering, Massachusetts Port Authority; Topic - Massport Construction Program.

A luncheon is planned for May 19, 1982, at which Elliot D. Michaelson of the International Executive Service Corps will speak of the work of the Corps in arranging for retired professionals to give of their skills to third world countries.

Respectfully submitted,
Brian R. Hogan, Chairman

Report of Nominating Committee, 1981-1982

The Nominating Committee, which met on 22 October 1981, 12 November 1981, 3 December 1981, and 17 December 1981, was composed of the following members:

Howard Simpson, Chairman (Senior Past President)
William S. Zoino, Vice Chairman (Past President)
Frank E. Perkins, (Past President)
Domenic E. D'Eramo
Richard A. Foley
Saul Namyet
Richard J. Scranton
Paul A. Taurasi
David E. Thompson (Elected Clerk)

The Committee recommends that the following members be endorsed by BSCE Section for membership on ASCE National Professional Committees to represent Zone I. All candidates have accepted; the appropriate Professional Division Committee Nomination Forms will be submitted to President Kinner.

Committee	*Nominee*
Professional Practice Division	
Executive Committee (PRODEX)	William S. Zoino
Education Division	
Executive (EDEX)	Clive L. Dym
Curricula and Accreditation (CC&A)	Steve J. Poulis
Subcommittee on Technology Curricula & Accreditation (STC&A)	Charles A. Rosselli
Engineering Management Division	
Engineering Management at the Organization Level (EMOL)	Charles C. Parthum

The Committee has previously submitted its recommendation that the name of Russel C. Jones be submitted to the New England Council as BSCES nominee for the Zone I, District 2 candidate for President-Elect of ASCE 82-83.

The Committee nominates the following members to be listed on the ballot for positions on the BSCES Board of Government and the Nominating Committee:

President:	Stanley C. Rossier
Vice-President (2-year term):	John P. Sullivan
Secretary:	Rodney P. Plourde
Treasurer:	Richard F. Murdock
Directors (2-year term):	David E. Thompson
	Rubin M. Zallen

Nominating Committee (2-year term; three to be elected):

Steven Bernstein
Varoujan Hagopian
Glenn Orenstein
Asaf A. Qazilbash
Charles A. Rosselli
Robert A. Snowber

All the above have agreed to be nominated.

Respectfully submitted,
Howard Simpson, Chairman

Report of Operations Manual Committee, 1981-1982

Revision of The Operations Manual is an ongoing process reflecting needs by various members and actions by the Board of Government. The following changes have been recommended during the past year:

1. Revisions to duties of Elected Officers and Executive Director reflecting (a) the establishment of a Budget Committee, (b) naming the Sr. V.P. as Budget Committee Chairman, (c) empowering the Secretary to sign checks in the absence of the Treasurer for bills approved by the Executive Director and President, (d) further describing duties of the Treasurer, (e) further describing duties of the Executive Director, and (f) refining the duties of the Auditing Committee;
2. Revisions to the duties of the Awards Committee for the purpose of including a series of ASCE distinguished award nominations previously overlooked by the BSCES, and
3. Revisions to the duties of the Action Program-Professional Practice Committee to include the making of appropriate recommendations for civil engineer candidates to be considered for appointive State and City Commissions and Boards.

The above recommendations have been submitted to the Board of Government and are under consideration for approval.

Respectfully submitted,
Stanley C. Rossier, Chairperson

Report of Program Committee, 1981-1982

The Program Committee coordinated the scheduling of all meetings to which the membership was invited, including:

Functions sponsored by Technical Groups
Functions sponsored by Committees
Monthly Luncheons
Functions sponsored by BSCE Section

Dates were allocated to Committees and Groups during June of 1981, and the Chairman maintained an up-to-date calendar of events. All changes in scheduled dates were coordinated through the Chairman. Special care was taken to avoid conflicts with BSCES events, or with events scheduled by other associated professional groups, and to avoid holidays.

Emphasis was given to the joint sponsoring of events when appropriate, by two Technical Groups, with other professional societies, or with local ASCE Student Chapters.

Respectfully submitted,
Richard J. Scranton, Chairman

Report of the Publications Committee, 1981-1982

Publications during this past year have included two issues of the BSCES Journal, published as Volume 67, Nos. 3 and 4, and ten issues of the Monthly Newsletter. The circulation of the Journal is approximately 2,000 copies per issue including over 1,400 members, over 300 to libraries and the remainder to fulfill special requests including mailings overseas.

A publication highlight of our Section was the special Freeman Edition of the Journal entitled "Boston's Charles River Basin - An Engineering Landmark" made possible through a subsidy from the John R. Freeman Fund Committee together with much creative dedication from Lee Marc G. Wolman and Edward C. Keane. The continuing dedication to our Newsletter by Susan Albert and Rubin Zallen are also greatly appreciated.

Our committee expresses a special tribute to Journal Editor Edward C. Keane for his excellent work and dedicated service over the past seven years. He is retiring as Editor upon completion of the spring 1982 issue, and we extend many thanks for a job superbly done!

Commencing with this issue, Vol. 68, No. 1, there will be two issues per year. A guide to authors is included in the present issue, and we urge all readers to contribute articles and papers for publication in forthcoming isssues.

Respectfully submitted,
Stanley C. Rossier, Chairman

Report of Public Relations Committee, 1981-1982

The Public Relations Committee this year was composed of the following members:

Robert J. Dunn, Jr.
Douglas F. Reed
Burt B. Jamison
David A. Spieler

Now well into the third year since its re-establishment the Committee has settled down to conducting its regularly established business of providing continued awareness of the accomplishments of its members within both ASCE and the BSCE Section and enhancing the public's awareness, understanding and appreciation of civil engineering and the civil engineer as a "People Serving Profession".

This years activities included:

— Assisting the Freeman Fund Committee in its efforts to distribute the Charles River Basin issue of the BSCES Journal to area book stores for sale to the general public.

— Preliminary consideration of preparing public service spot advertisements for airing on local television stations which highlight area projects and exemplify the civil engineering profession.

At the January 18, 1982 Board of Government meeting the Public Relations Committee reported that it had received one entry for the Mass. OCEA award competition. The Committee suggested that the local competition deadline be moved back so that the winner of the competition could then be entered in the ASCE National Competition. The Committee further suggested that the entry also be held over to allow more time for additional submittals and that the winner of the local competition could then automatically be entered in the ASCE National Competition.

The chairman wishes to thank the Committee members for their active participation and to all those who supported its efforts.

Respectfully submitted,
Robert J. Dunn, Jr., Chairman

Report of Retired Engineers Service Committee

At the Annual Meeting of the Board of Government, held on May 26, 1981, a new committee was established under the chairmanship of Robert Snowber, to develop a program which would identify opportunities in public service for retired civil engineers. Other members of the Committee are Bruce Campbell and Peter Dyson. Particular emphasis will be placed on the International Executive Service Corps (IESC) and the May monthly luncheon will be addressed by Mr. Eliot Michaelson, Boston Field Advisor for the IESC. Mr. Michaelson has completed five assignments in under-developed countries for the organization. Domestic programs will also be discussed.

Respectfully submitted,
Robert A. Snowber, Chairman

Report of Seismic Design Advisory Committee, 1981-1982

The Seismic Design Advisory Committee was established by BSCES/ASCE Board of Government at its September 1981 meeting.

The initial committee consists of the following members:

Rene W. Luft	Chairman
Gonzalo Castro	Vice Chairman
Norton S. Remmer	Secretary
J. Timothy Anderson	Member
James A. Becker	Member
Myle J. Holley, Jr.	Member
Edward B. Kinner	Member
Thomas M. Payette	Member
Maurice A. Reidy, Jr.	Member
Kentaro Tsutsumi	Member
Robert V. Whitman	Member
Kenneth B. Wiesner	Member

The Seismic Design Advisory Committee has held the following two regular meetings:

December 14, 1981 — The first meeting of the committee was devoted to the election of officers, to the schedule of meetings for 1982, to defining the rules of operation for the committee, and to developing the agenda for 1982. The following topics constitute the agenda:

- Review the section on earthquake loading of ANSI A58.1 - 1982.
- Compile minimal upgrades for old buildings and develop rules for renovation of existing buildings.

- Review the soil factor, the response spectrum, and the liquefaction provisions of the current State Building Code.
- Review the seismic zoning and the zone factor of the current State Building Code.
- Establish a feedback mechanism with the engineers, architects, building officials, and builders in the state who are interested in offering comments on the earthquake provisions of the State Building Code.

The Chairman appointed a subcommittee for each topic on the agenda.

February 22, 1982 — At the second meeting the subcommittees presented the reports of their work. Tentative recommendations were to maintain Massachusetts as one seismic zone, to adopt a soils factor similar to that of ATC 3-06, and to update the response spectrum and the liquefaction provisions.

The committee also discussed its role in developing earthquake requirements for hazardous waste facilities. The committee will, if necessary, assist the BSCES committee on hazardous waste.

Future meetings scheduled for 1982 will be held on April 12, June 14, August 9, October 4, and December 13.

Respectfully submitted,
Rene W. Luft, Chairman

Report of Social Functions Committee, 1981-1982

Two functions were sponsored this year by the Social Functions Committee. They were the clambake on August 12, 1981 and the winter dance on February 20, 1982.

Once again the clambake was an enormous success attracting a record 304 BSCES members and guests who feasted on an excellent dinner of lobster or chicken. Twenty one prizes were handed out. A great time was had by all and in addition a profit of $669.62 was made. Plans should be made to have another clambake this summer.

The winter dance was held under the dome of the Great Hall at Quincy Market. The dome setting was beautiful and excellent music was provided by the Nick Michaels Band. All those in attendance had a great time; unfortunately only 94 BSCES members and guests attended and a loss of $706.90 was incurred.

While the attendance was up 20% from the previous dance, it was disappointing considering the effort put in by the Dance Committee to generate interest.

Considering the apparent lack of interest on the part of members in the recent dances and the financial losses sustained by BSCES, the Social Functions Committee recommended that the annual dance be discontinued.

Respectfully submitted,
Mathew A. DiPilato, Chairman

Report of Student Affairs Committee, 1981-1982

The committee this year consisted of: Steven Bernstein, Chairman, Michael Kupferman, Adrienne Dill, Michael Gaa, Jospeh Allegro, Charles Button, William Griffin, Thomas Taddeo, and Richard Scranton.

The committee has met throughout the year; activities were as follows:

Contact Members: Checked on contact members for all universities and prepared contact member handbook.

Officer Caucus: October 6, 1981 - Conducted Officer Caucus, where each Student Chapter had the opportunity to present its planned year of activities and to meet the Board of Government and technical chairmen.

Project Funds: SAC presented a new project, the funding of student projects (any except social) up to $500. One such project, LCDC student project of Northeastern University, was awarded $500.

Free Lunch: In order to promote better student attendance at technical meetings SAC offered the *Free Lunch* program during January and February, 1982. This program covers the cost of the half price dinner of the student. Eight students took advantage of this program.

Student Loans: Two $1000 interest-free loans were awarded this year to:

- Brian Holmes - U of Lowell
- George T. Samoil - U of Lowell

Solicitations from businesses this year yielded $1050, from the following firms:

Camp, Dresser & McKee, Inc.
Richard J. Donovan, Inc.
Fay, Spofford & Thorndike, Inc.
Gale Engineering Co., Inc.
Geotechnical Engineers, Inc.
Goldberg-Zoino & Associates, Inc.
Haley & Aldrich, Inc.
Keyes Associates
Maurice A. Reidy, Engineer
J. F. White Construction Co.

Howe-Walker & Other Awards:
The following awards were made at Student Night:

Desmond Fitzgerald Award	Carol J. Lemb Northeastern University
William P. Morse Award	Leonard Albano Tufts University
Howe-Walker Awards	
Massachusetts Institute of Technology	Martin S. Liss
Merrimack College	Alessandro Martignetti
Northeastern University	Paul P. Livernois Joanna M. Kripp
Southeastern Massachusetts University	Carol A. Rego
Tufts University	Jennifer Bryant
University of Lowell	Helene B. Demetroulakis
Wentworth Institute of Technology	Theodore L. Scott
Worcester Polytechnic Institute	Annie L. Autio

Student Night: This year Student Night was held on March 4, 1982 at SMU. Ninety-six persons were in attendance. The speaker was Richard Pierce, Assistant Secretary of Consumer Affairs for Commonwealth of Massachusetts and his talk was entitled "Self Help Approach to Resolving Consumer Problems." Awards were presented.

Student Membership Grade: The SAC discussed the Section's concern about the Student Membership Grade of membership and made recommendations to the By-Laws Committee.

In 1982-1983, SAC intends to bring Student Chapters closer to the BSCE Section through better communications and program activities.

Respectfully submitted,
Steven L. Bernstein, Chairman

ANNUAL REPORTS OF TECHNICAL GROUPS

Report of Computer Group, 1981-1982

The executive Committee this year consisted of the following:

Glenn S. Orenstein	Chairman
Mukti Das	Vice Chairman
Ziad Ramaden	Clerk
Gonzalo Castro	Member
Jack Horgan	Member
John D. Goodrich	Member

As of this date, three regular meetings of the Computer Group have been held as follows:

September 23, 1981 — At the M.I.T. Hydraulics Laboratory. Held jointly with the Hydraulics Group and Energy Committee . Dr. Alexander Gorlov of Northeastern University spoke on "A Novel Approach to Harnessing of Tidal Energy".

November 4, 1981 — Dinner meeting at the Engineers Club. Held jointly with the Énergy Committee. Mr. Arthur H. Boyle of the New England Telephone Company spoke on "Energy Conservation Systems in N.E. Telephone Company Buildings." Attendance, 20.

March 2, 1982 — At M.I.T. Joint with the Structural Group. Dr. Christian Meyer, Professor of Civil Engineering at Columbia University, spoke on "Computer Analysis and the Design of Structures". Attendance, 45.

May 6, 1982 — The Computer Group will sponsor a lecture and demonstration of interactive drafting equipment. Dr. Jack Horgan of Applicon will speak. There will be a fee of $4.00. It is anticipated that 50 people will attend. This will be an official meeting of the BSCE Section.

As a result of fees to be collected at the May 6 meeting, I anticipate completing the year without a deficit.

Officers of the Computer Group for 1982-1983 will be as follows:

Mukti L. Das	Chairman
Ziad Ramaden	Vice Chairman
Gonzalo Castro	Clerk
Jack Horgan	Member
Glenn S. Orenstein	Member
Plus one member not yet elected.	

Respectfully submitted,
Glenn S. Orenstein, Chairman

Report of the Construction Group, 1981-1982

The Executive Committee this year consisted of the following members:

Chairman	Donald W. Nickerson
Vice Chairman	Mark P. Tedeschi
Clerk	Thomas Taddeo
Member	Charles A. Rosselli
Member	John R. Roma
Member	Stephen G. Walker

Meetings of the Construction Group held during the past year were as follows:

October 8, 1981 — Dinner meeting at the M.I.T. Faculty Club. Mr. Richard K. Guzowski, Northeast Regional Manager of Reinforced Earth Company presented slides and discussed the many advantages of using a reinforced earth retaining wall system. Attendance: 32.

January 20, 1982 — Joint dinner meeting with the Geotechnical Group at the Engineers Club. Mr. John Dugan of Haley and Aldrich and Mr. Thomas Gunn of Turner Construction Company discussed the details and complexities of the foundation pile installation at the Copley Place Project. Mr. Gunn elaborated on the slipformed concrete core construction method utilized on the new Westin Hotel. Attendance: 114.

March 10, 1982 — Joint dinner meeting with the Transportation Group at the Engineers Club. A panel of speakers consisting of representatives from the contractors and the MBTA discussed problems encountered and techniques to overcome them on their respective Southwest Corridor contract. Attendance: 98.

Officers and Executive Committee Members for the 1982-1983 year are as follows:

Chairman	Mark P. Tedeschi
Vice Chairman	Thomas Taddeo
Clerk	Charles Costello
Member	Donald W. Nickerson
Member	Charles A. Rosselli
Member	John R. Roma

Respectfully submitted,
Mark P. Tedeschi, Vice Chairman

Report of Environmental Group, 1981-1982

The Executive Committee of the Environmental Group for 1981-1982 consisted of the following:

Chairman	Gerald C. Potamis
Vice Chairman	James C. O'Shaughnessy
Clerk	Edward Boyajian
Member	Richard K. Smith, Jr.
Member	Stephen H. Geribo
Member	Peter M. Smith

The Environmental Group held the following meetings:

October 1, 1981 — Joint dinner meeting with Geotechnical Group at the Engineers Club. Richard M. Doherty, General Counsel for Camp, Dresser and McKee and Harl P. Aldrich, President of Haley and Aldrich, discussed professional liability of engineers. Attendance, 75.

December 3, 1981 — Joint dinner meeting with the Energy Committee at Polcari's Restaurant. Mr. Walter R. Neissen, Vice President, Camp, Dresser and McKee, spoke on "Waste to Energy - Facts and Speculation." Attendance, 35.

February 23, 1982 — Dinner meeting at Victoria Station, Boston. Messrs. Jack D. Bonomo and Ron J. Rose, Senior Operations Specialists, Metcalf and Eddy, made a presentation entitled "Approaches to Operations and Maintenance Problem Solving at Wastewater Treatment Plants." Attendance, 55.

April 14, 1982 — Dinner meeting at Northeastern University. Dr. Walter J. Weber, Professor, University of Michigan will give a presentation entitled "Adsorption in Water and Wastewater Treatment; Overview and Perspectives." This will also be the annual Thomas R. Camp Lecture. Attendance

May 11, 1982 — The annual field trip will be a tour of the Wilmington, Massachusetts Water Treatment Plant. Mr. Leo Peters, Executive Vice President and Alan Silbovitz, Director, Water Division, Weston and Sampson, will speak on the project at a dinner meeting following the tour. This meeting is also the annual election meeting for the Environmental Group. This is an official meeting of the BSCE Section.

The following officers have been nominated for 1982-1983:

Chairman	James C. O'Shaugnessy
Vice Chairman	Edward Boyajian
Clerk	Richard K. Smith, Jr.
Member	Stephen H. Geribo
Member	Peter M. Smith
Member	Sara J. Simon

Respectfully submitted,
Gerald C. Potamis, Chairman

Annual Report of Geotechnical Group, 1981-1982

The following were officers of the Geotechnical Group this year.

Chairman	Asaf Qazilbash
Vice Chairman	Dr. Lewis Edgers
Clerk	James W. Weaver
Member, Executive Committee	Joseph Engels
Member, Executive Committee	Nuri Georges
Member, Executive Committee	Bruce Beverly
Chairman, Forum Committee	Bruce Buttner (Resigned)
	Javed Sharwani (Successor)

The Group held the following meetings this year:

October 11, 1981 — "Tort Liability - Role of the Engineer", presented by Richard Doherty, General Council, Camp, Dresser & McKee, Inc., and Dr. Harl Aldrich, President, Haley & Aldrich, Inc., at the Engineers Club. This was a joint meeting with the Environmental Group. Attendance, 75.

November 12, 1981 — "Unexpected Conditions, or the Application of the Observational Approach", presentation by: Ronald C. Hirschfeld - Geotechnical Engineers, Inc.; William S. Zoino, Goldberg Zoino & Associates, Inc.; David E. Thompson, Haley & Aldrich, Inc.

The meeting was sponsored by the Forum Committee and was held at the Engineers Club. Attendance, 80.

January 20, 1982 — "Foundation Construction of the Copley Square Project", presented by John P. Dugan, Haley & Aldrich, Inc., and Thomas P. Gunn, Turner Construction Company at the Engineers Club. The meeting was sponsored jointly by the Forum Committee and the Construction Group. It was also an official meeting of the BSCE Section. Attendance, 114.

February 25, 1982 — "Geotechnical Aspects of Earth-Sheltered Building Design and Construction", presented by Dr. Raymond Sterling, Director of Underground Space Center, University of Minnesota, at the M.I.T. Faculty Club. This was a joint meeting with the Ad-Hoc Energy Committee. Attendance, 73.

March 16, 1982 — "Criteria for Siting Hazardous Waste Treatment Facilities in Massachusetts", presented by John Schofield, IT Corporation, Wilmington, California, at the Engineers Club. The meeting was sponsored by the Forum Committee. Attendance, 75.

March 24, 1982 — "Massport Construction Program", presented by David Weiner, Director of Engineering, Massachusetts Port Authority at the Great Hall, Quincy Market. The meeting was one of the regular monthly luncheons. Attendance, 118.

April 22, 1982 — "John R. Freeman and the New Technology" presented by Dr. Harl Aldrich, Haley & Aldrich, Inc., at M.I.T. The paper described the founding and development of the Cambridge campus of M.I.T., sometimes called "The New Technology", also another "new technology" called soil mechanies.

Officers and Executive Committee members for 1982-1983 are as follows:

Chairman	Dr. Lewis Edgers
Vice Chairman	James W. Weaver
Clerk	Joseph G. Engels
Member, Executive Committee	Nuri T. Georges
Member, Executive Committee	Bruce E. Beverly
Member, Executive Committee	Javed A. Sharwani

A committee has been appointed to hold a lecture series in the Fall of 1982, to be entitled "Engineering Geology."

Another committee has been appointed to organize and conduct a short course on Soil Mechanics in the summer of 1983. This committee will raise funds for the 1985 Conference of the International Society of Soil Mechanics and Foundation Engineering.

Respectfully submitted,
Asaf A. Qazilbash, Chairman

Report of Hydraulics Group, 1981-1982

The Executive Committee for this year consisted of the following members:

Chairman	Varoujan Y. Hagopian
Vice Chairman	Paul F. Shiers
Clerk	David A. Spieler
Member	Richard J. DiBuono
Member	Edward P. Dunn
Member	Dean K. White

Meetings held by the hydraulics group are summarized below:

September 23, 1981 — Evening meeting at Ralph W. Parsons Water Resource Laboratory, M.I.T. Ed. Kinner, (President of BSCES/ASCE) spoke of coming BSCE events and future society activities. Dr. Alexander Gorlov of Northeastern U. spoke on "A Novel Approach to Harnessing of Tidal Energy" by utilizing tidal fluctuation to compress air for driving gas turbines and generators.

October 21, 1981 — Evening meeting at Water Resources Laboratory, M.I.T. Subject was Math Modeling and Computer Simulation of a Cascading System of Hydroelectric Plants. Dr. C.K. Sarkar presented an overview of a computer simulation model developed at Chas. T. Main Inc. to estimate energy output from a series of hydroelectric plants on a single stream.

January 13, 1982 — Evening meeting at Water Resources Laboratory, M.I.T. Subject was "Fish Passage Facilities at New England Electric System's Cnnnecticut River Hydro Projects." Barry A. Ketschke of N.E. Electric System presented an overview of NEES's anadromous fish restoration objectives for the Connecticut River and reviewed some of the legislation which promoted this effort. Johannes Larsen of Alden Research Laboratory discussed details of the hydraulic model built by Alden Labs and used in designing the Vernon Dam Fishway. Denton E. Nichols, of N.E. Electric Systems shows slides and described the construction process for the fishway and the many unique features of the $9.5 million project. This was also an official meeting of the BSCE Section.

March 31, 1981 — Evening meeting at Water Resources Laboratory, M.I.T. Subject was Mississippi River Surveillance at the old river structure to protect the control structure from errant barges. Leonard J. Peterson of Raytheon Service Company described the methods of control used.

April 21, 1982 — A dinner meeting at the Bush Room, M.I.T., is scheduled in conjunction with M.I.T. Student Chapter of ASCE. This will be the 11th Freeman Memorial lecture. The paper to be presented by Prof. Gerhard H. Jirka of Cornell is entitled "Multiport Diffusers for Heat Disposal" and is the paper that won this year's $2,500 prize, awarded by the Section's John R. Freeman Fund Committee.

May 26, 1982 — A combined lecture/field trip is scheduled. Topic and place will be selected in the near future.

Hydraulics Group Officers for 1982-1983 were elected at the April meeting. The Executive Committee for the coming year will include the following:

Chairman	Paul F. Shiers
Vice Chairman	David A. Spieler
Clerk	Athanasios A. Vulgaropoulos
Member	Richard J. DiBuono
Member	Edward P. Dunn
Member	Dean K. White
Member	Varoujan Y. Hagopian

Respectfully submitted,
Varoujan Y. Hagopian, Chairman

Report of Structural Group, 1981-1982

The Executive Committee this year consisted of the following members:

Chairman	Kenneth B. Wiesner
Vice Chairman	Maurice A. Reidy, Jr.
Clerk	Thomas Tsotsi
Member at Large	Emile W.J. Troup
Member at Large	Morris S. Levy
Member at Large	Nicholas Mariani
Student Member	Brian Brenner, M.I.T.
Immediate Past Chairman	James M. Becker

The Structural Group held the following meetings this year:

September 30, 1981 — Professor T.V. Galambos, University of Minnesota, presented the 1981 AISC T.R. Higgins Lectureship Award paper entitled "Load and Resistance Factor Design for Steel". The meeting was held at the Center for Advanced Engineering Studies, M.I.T. Attendance, 71.

February 3, 1982 — Five speakers presented the background for and discussed issues concerning Copley Place, major urban development project adjacent to Boston's Copley Square: Kenneth A. Himmel of Urban Investment and Development Company, Howard Elkus of The Architects Collaborative, Morris S. Levy of Parsons Brinckerhoff Quade and Douglas, Michael J.A. Joliffe of Zaldastani Associates, and Dr. Charles H. Thornton of Lev Zetlin Associates. The meeting was held at the Ell Student Center, Northeastern, and it was also an official meeting of BSCE Section. Attendance, 120.

March 2, 1982 — Professor Christian Meyer of Columbia University was speaker at a combined meeting of the Computer and Structural Groups on "Computer Analysis and Design of Structures". Attendance, 50.

April 1, 1982 — Professor Steven J. Fenves of Carnegis-Mellon University spoke on "Trends in Structural Design and Materials Through the History of Pittsburgh Bridges" This was a dinner meeting held at the Faculty Club of M.I.T. Attendance, 40.

At this meeting elections were held for the Executive Committee for the coming year. The Executive Committee for 1982-1983 will include:

Chairman	Maurice A. Reidy, Jr.
Vice Chairman	Thomas Tsotsi
Clerk	Emile W.J. Troup
Member at Large	Morris S. Levy
Member at Large	Nicholas Mariani
Member at Large	Richars Savage
Student Member	Michael Bohn, Northeastern
Immediate Past Chairman	Kenneth B. Wiesner

Sructural Group Lecture Series

A lecture series entitled "Design of Building Cladding" was presented by the Structural Group in cooperation with M.I.T., at the Green Building of M.I.T. Average attendance was 200. Subjects and speakers were:

October 13, 1981 Jack Heitmann	Principal Antoine-Heitmann & Assoc. St. Louis, Missouri	"Introduction to Building Cladding"
October 21, 1981 Alan Dalgliesh	Head, Building Structures Section Division of Building Research National Research Council Ottawa, Canada	"Cladding Design For Wind"
October 27, 1981 Robert McKinely	Manager, Technical Services (Ret.) Flat Glass Division PPG Industries Pittsburgh, PA	"Design of Glazing Systems"
November 3, 1981 Philip Zinn, AIA	Architect and Construction Manager Fisher Brothers Management Corp. New York, NY	"Design of Metal Curtain Walls'
November 10, 1981 Jerry Stockbridge	Consultant Wiss, Janney, Elstner & Assoc. Northbrook, IL	"Design of Masonry Cladding"
November 17, 1981 Thomas J. Escedi	T.J. Escedi & Associates, Ltd. Downsview, Ontario	"Design of Precast Concrete Cladding"
December 1, 1981 A.A. Sakhnovsky	President Construction Research Laboratory Miami, FL	"Cladding Problems-Prevention, Analysis and Cure"

A bound Proceedings volume was printed, including papers from the first six speakers of the Series.

Respectively submitted,
Kenneth B. Wiesner, Chairman

Report of Transportation Group, 1981-1982

The Executive Committee of the Transportation Group in 1981-1982 included the following:

Robert A. Snowber	Chairman
Paul A. Levy	Vice Chairman
Francis H. McCarran	Clerk
Robert J. Tierney	Member
Frank Sholock	Member
Guy Denizard	Member
Edmund J. Condon	Member, Past Chairman
Marvin W. Miller	Representative to JRTC

The Group held four meetings in 1981-1982 as summarized below. The five-session lecture series on "Stress Management" is scheduled to start April 13, 1982 and an additional technical meeting is scheduled for May 13, 1982.

September 24, 1981 — Joint meeting with the Society of American Military Engineers, held in the Great Hall of Quincy Market. William K. Hellman, Transportation Coordinator of Baltimore, spoke on the design and construction of the Ft. McHenry Tunnel. This was also the first in this year's Monthly Luncheon Series and an offical meeting of the BSCE Section. Attendance, 135.

November 12, 1981 — Luncheon meeting at Polcari's Restaurant. State Representative Louis Nickinello, Chairman of the Joint Committee on Transportation, addressed the Group on the "State Transportation Bond Issue - Its Need and Benefits". Attendance, 72.

January 28, 1981 — Luncheon meeting at Polcari's Restaurant. Theodore H. Karasopoulis, Chief Bridge Engineer of Maine DOT, spoke on "Segmental Bridge Design Experience in Maine." His emphasis was on the Wiscasset Bridge, now under construction. Attendance, 104.

March 10, 1982 Meeting — Annual Meeting of the Group, held at the Engineers' Club, Boston. It was a joint meeting with the Construction Group. The subject of the meeting was the "Southwest Corridor - Construction Techniques." Alfred Pacelli, Deputy Director of Construction for the MBTA, headed a panel including also Peter Martin of the J. F. White Contracting Corporation, Ivan Janowsky, Schiavone Construction Corp., and George Crawford of Salah & Pecci, Inc. Attendance, 98.

The Group's Executive Committee for 1982-1983 will include the following:

Paul A. Levy	Chairman
Francis H. McCarran	Vice-Chairman
Robert J. Tierney	Clerk
Frank Sholock	Member
Guy Denizard	Member
David Weiner	Member
Robert A. Snowber	Member, Past Chairman
Marvin W. Miller	JRTC Representative

Respectfully submitted,
Robert A. Snowber, Chairman

Report of Waterways, Port, Coastal and Ocean Technical Committee, 1981-1982

In response to apparent interest in organizing a separate technical group concerned with waterways, port, coastal and ocean, the Board of Government discussed the matter on June 15, 1981, and approved polling of the membership. Subsequently, a memorandum with a form to indicate interest was mailed to the membership. After receiving a signficant number of positive responses from the membership, and further discussions, the Board of Government established for one year and Ad Hoc Waterways, Port, Coastal and Ocean Technical Committee on December 21, 1981.

An informal committee organized the first meeting, held at the M.I.T. Faculty Club on March 3, 1982. Seven members were elected to an executive committee, with officers as follows:

Kenneth M. Childs, Jr.	Chairman
Peter Majeski	Vice-Chairman
Louis R. Nucci	Clerk
Athanasios A. Vulgaropulos	Secretary
William J. Pananos	Member
John B. Creeden	Member
Alexander Surko, Jr.	Member

Three talks were given on "Effects of the 1978 Blizzard on the New England Coast" by Richard J. DiBuono, W. Frank Bohlen and John W. Gaythwaite. Mr. DiBuono discussed the climatological and meteorological aspects of tides and storms, as well as the characteristics of the February 1978 blizzard. Mr. Bohlen discussed some of the shore processes of erosion and accretion of the bottom during the storm in the Revere Beach and Lynn Beach areas. Mr. Gaythwaite discussed the effects of the storm tides and waves on the various types of waterfront structures. Attendance was about 50.

Respectfully submitted,
Athanasios A. Vulgaropulos, Secretary

ANNUAL REPORT OF THE WESTERN MASSACHUSETTS BRANCH

Editor's Note: Following is an abstract of the annual report of the Western Massachusetts Branch (WMB), the original of which is on file at the BSCE Section office, 80 Boylston Street, Boston, MA 02116. It covers activities from March 31, 1981 through March 31, 1982 and also lists proposed Branch activities through August, 1982.

INTRODUCTION

Officers

For the period September 1981 through September 1982, WMB officers were as follows:

President	Walter Schwarz
Vice President	Willian H. Hover
Treasurer	Paul A. Kozlowski
Secretary	Paul H. Kwiatkowski
Newsletter Editor	Lawrence E. Smith

The Board of Directors consists of the first four officers above and Dr. John Collura, 1980 Past President,

SUMMARY OF ACTIVITIES

Dinner Meetings

April 28, 1981. Field trip to Stoney Brook Energy Center, Ludlow, Mass. Dinner at Roadway Inn, Chicopee.

May 28, 1981. Joint meeting at Howard Johnson's, Newton, with BSCE Section's Geotechnical and Construction Groups. Speaker, Mr. Allen Hulshizer of United Engineers; subject, Seabrook Power Plant Tunnels.

October 14, 1981. At Lord Jeffrey Inn, Amherst. Speaker, Dr. Lawrence Feldman of Goldberg Zoino & Associates. Subject, Hydrogeological Aspects of Hazardous Waste Sites in New England.

February 10, 1982. At Top of the Campus, Amherst. Mr. Eugene F. Casey, P.E., of Mason and Hanger-Silas Mason, Inc. Subject, Tunneling and Underground Construction Below East River, New York.

Dinner meetings are also scheduled for April 14, 1982 and May 11, 1982.

Board of Government Meetings

The WMB Board of Directors held meetings in connection with dinner meetings, or scheduled them separately in months when dinners were not held. (Minutes are included with the full report.) A member of the WMB attended BSCE Section's Board of Government meetings periodically.

Continuing Education

On June 29 and 30, 1981 a two-day conference on Transportation Management was held at Mount Holyoke College, to discuss revitalization and transportation planning in cities of Massachusetts. Co-sponsor with WMB was the Civil Engineering Department, UMass Amherst.

A one-day conference on Hazardous Waste is planned for June, 1982 at Mount Holyoke.

New England Council and Zone I Meetings

The New England Council met at M.I.T. on September 18, 1981 with representatives present from the several New England Sections, and discussed matters of regional and national concern. (Minutes are included with full report.)

New England Section representatives met again at M.I.T. on December 4, 1981, and voted to support the candidacy of S. Russell Stearns for national President-Elect.

Representatives of Zone I Sections (New England and other) met on January 28, 1982 in New York, and voted to support the candidacy of S. Russell Stearns for national President-Elect.

A Zone I Management Conference was held on January 28-29, 1982 in New York, attended by a WMB representative, for discussion of Section and Branch management, aids available from national, etc. There will be a national membership drive this year.

National Historical Civil Engineering Landmark (NHCEL)

After much work by ASCE personnel in this area, the National Board of Direction voted on December 14, 1981 to designate the Borden Base Line as an NHCEL. The 7-mile base line was laid out and measured by Simeon Borden in 1839, with precision unprecedented for that era.

Newsletter

A WMB Newsletter is being planned, with first issue in May, 1982.

BUDGET OF 1981-1982 AND PROJECTED BUDGET FOR 1982-1983

ITEM	BUDGETED 1981-1982	ACTUAL 1981-1982	TENTATIVE BUDGET 1982-1983
Dinner Meetings:			
Speaker Meals and Expenses	$ 130.00	$ 62.78	$ 95.00
Dinner Subsidy	300.00	302.35	250.00
Student Chapter Support	50.00	112.00	100.00
Workshop			
(TSM/CBD Conference)	150.00	134.98	150.00
Lecture Series			
(Hazardous Waste)	150.00	90.00	0.00
Continuing Education	0.00	0.00	150.00
Postage and Printing	400.00	305.01	300.00
Awards	10.00	52.45	12.00
Officers' Expenses	100.00	68.80	125.00
Accounting		4.30	
Totals	$1,290.00	$1,132.67	$1,182.00

Appendices

The several appendices of the full report contain additional details, including minutes of Board meetings, etc.

The WMB now has a post office box: P.O. Box 387, Amherst, MA 01004

GUIDE TO AUTHORS

of Papers Submitted for Publication in BSCE Section Journal

Papers on subjects related to civil engineering, either technical or professional, will be welcomed and considered for publication in the BSCE Section Journal. They should be delivered in duplicate, either to a chairperson of one of our Technical Groups or to the Publications Committee, BSCE Section, ASCE, 80 Boylston Street, Boston, Massachusetts 02116.

After review, the author will be notified, either that the paper is accepted, accepted with changes suggested by reviewers, or not considered suitable for the Journal.

Each paper must be the original work of the authors. If published or offered for publication elsewhere, this should be mentioned. The manuscript should be typed double-spaced on one side of 8½" x 11" paper. The first page should state the title and the author's name, organization and position. If presented as a lecture, either at one of the Section's Technical Group meetings or elsewhere, a footnote stating this should be provided. Oral presentation, or membership in BSCES or ASCE, are not necessary for eligibility to submit papers, or for papers to be considered for certain prizes awarded annually.

Figures are to be original blackline drawings or clear prints, with line values and lettering suitable for printing when reduced to fit the page space, 4½" by 6½". Photographs must be black-and-white glossy prints.

The style of the paper should, in general, conform to the current requirements of ASCE. ASCE now encourages authors to write in the active voice and to avoid awkward phraseology by writing in the first person, where this would be natural.

Each author of a published paper receives ten copies of the Journal issue in which the paper appeared. Reprints may be arranged for, if desired.

January 1982

C/R

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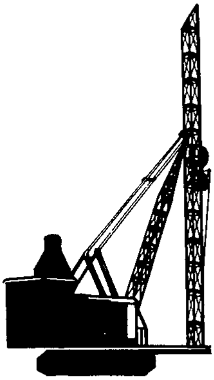

BOSTON SOCIETY OF
CIVIL ENGINEERS SECTION ASCE

Committee Chairmen, 1982-1983

Committee	*Chairman*
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Division Chairmen

Division	*Chairmen*
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PROFESSIONAL & SOCIETY AFFAIRS	Rubin M. Zallen
TECHNICAL	Judith Nitsch
GENERAL TASKS	David E. Thompson

SPRING 1982

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