

## DEVELOPING A GRADUATE PROGRAM IN NUCLEAR WASTE MANAGEMENT/FACILITY RESTORATION

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### ABSTRACT

A graduate program leading to the degree of Masters of Engineering with a concentration in Nuclear Waste Management/Facility Restoration is being offered by Manhattan College. The Program, which was initiated in the Fall 1990 semester, is offered under the auspices of the Department of Mechanical Engineering at both the College's campus in the Riverdale section of New York City, and the training facility of the New York Power Authority at Indian Point. The Program is designed to provide the student with a core of practical, specialized courses in Waste Management, Facility Restoration, and related technology supplemented by graduate courses in other engineering disciplines. It is designed to meet the needs of both full and part time students. Response to the Program has been excellent with 3 full time and 37 part time students enrolled and 9 additional students taking prerequisites to qualify for admission to the Program. An internship program has also been established with local firms.

### INTRODUCTION

The Department of Mechanical Engineering at Manhattan College has expanded its graduate program to offer a concentration in Nuclear Waste Management/Facility Restoration (the "Program") leading to the degree of Master of Engineering. The Program is designed to provide professionals with practical interdisciplinary course work of specific relevance to the technical, regulatory, and environmental aspects of this field.

#### Basis For Development Of The Program

Manhattan College is a 4,000 student private independent institution in the Riverdale section of New York City run by the Brothers of the Christian Schools. The Engineering School, with an enrollment of 850, offers bachelors and masters degrees in Civil, Chemical, Electrical, and Mechanical Engineering and masters degrees in Environmental Engineering.

The impetus for the establishment of the Program at the College derived from the coalescence of a number of factors including the prior existence of a body of relevant courses at the undergraduate and graduate level, faculty expertise and facilities available in several engineering departments, a recognized need for trained professionals in Nuclear Waste Management/Facility Restoration both regionally and on a national basis, the support of the College administration, and the expressed interest by local firms and utilities in participating in the program. These factors are discussed in some depth below.

At the undergraduate level, a one year sequence in nuclear engineering involving the nuclear laboratory had generated significant interest in the nuclear field and resulted in a number of graduating seniors entering the field each year. At the graduate level, the Mechanical Engineer-

ing Department offered courses in nuclear engineering, nuclear power systems, regulation and licensing of nuclear facilities and, in conjunction with the Environmental Engineering Department, radioactive and hazardous waste management. In addition, the 50 year old graduate program in Environmental Engineering with its emphasis on water quality, dispersion modeling, and water resources management had produced a large body of alumni who were in the waste management and related fields and were graduating an increasing number of masters degree recipients who were finding positions in waste management and site remediation. Civil engineering graduate courses in geology and hydrology, and Chemical Engineering graduate courses in hazardous waste incineration and emergency planning also contributed to a solid foundation in related technical areas.

Consistent with the offerings of these courses was the availability of faculty trained in disciplines of particular relevance to the Program, many of whom are nationally recognized for their expertise and serve as consultants to private firms and government agencies, including DOE. The substantial involvement of the authors as consultants in the Nuclear Waste Management/Facility Restoration field was of primary importance in developing the Program and selling it to the College administration. Their roles in Program management, course development and instruction, and involvement of industry and government were enhanced by their knowledge of current technology, environmental issues, and personnel needs in the field. As is subsequently described, the availability of relevant laboratory facilities, particularly the nuclear and environmental laboratories, provided the opportunity for training and research to support the course work in the Program and serve as a vehicle for obtaining external support.

The development of the graduate nuclear program has been the subject of study and analysis since 1985 at the

College. When the concept of evolution into the current Nuclear Waste Management/Facility Restoration Program was presented, the College administration gave this concept its full support. The Mechanical Engineering Department Chair, with the endorsement and support of the Dean of Engineering and the Provost, has worked closely with the authors to establish the Program elements, disseminate information, and enroll students.

A primary factor in the formalizing of the Program at this time is the recognized need for engineering professionals with specific relevant training in Waste Management and Facility Restoration. There are approximately 20 major engineering consulting firms, 4 utilities, and a number of architect-engineers, equipment suppliers, and service organizations within a one hour drive from the College who are directly involved in the field and who consistently advertise for trained personnel. Many of the College alumni are employed with these organizations, and have provided feedback as to the personnel needs. Further, the public and municipal governments in the region are quite sensitized to the needs for remediation and restoration at contaminated sites which has resulted in pressure for accelerated activities requiring expanded staffing. While there are a number of engineering schools in the New York Metropolitan area, there were no programs that met the specific needs of the area's firms for professionals with directly relevant training.

The need for trained professionals has been concretely expressed by the firms through their participation in the development and conduct of the Program. This has taken two forms: the development of an off site location for the Program in addition to the College, and the sponsorship of intern programs leading to full time positions. The New York State Power Authority Training Organization, upon hearing of the development of the Program, contacted us about establishing an off-campus program for their employees. Concurrent with the initiation of the Program at the College, a comparable graduate program has been established at the training facility of the Authority at Buchanan, New York to serve the professionals at Indian Point 3, the Authority's offices in White Plains, and the Consolidated Edison personnel at Indian Point 2. The facility, which is located about 40 miles north of the College, is also accessible to professionals from the companies in the area and convenient to those living in the northern New York City suburbs and the Hudson River Valley. The intern program, which is described in more detail below, is being developed with the consulting firms in the region to provide full time students the opportunity to complement their course work with relevant hands-on experience. An additional factor in assuring the viability of the Program at the College was the selection of Manhattan College in 1990 as one of the participating institutions in the Department of Energy's (DOE) Nuclear Waste Management/Environmental Restoration

Fellowships Program, and the award of the fellowship to one of our graduating seniors in May 1990.

#### Program Parameters

The Program is designed to provide the student with a core of practical specialized courses supplemented by related graduate courses in other engineering disciplines. Required courses are kept to a minimum, and the student is provided flexibility in tailoring a program to their career objectives.

Among the unique features of the Manhattan College Program are:

- The courses emphasize both accepted analytic practices and current technology in use in the field.
- The courses are taught by full time members of the graduate engineering faculty and adjuncts with extensive industrial and consulting experience in Nuclear Engineering, Waste Management and Facility Restoration.
- The Program provides access to the College's nuclear reactor laboratory, and environmental laboratories which are facilities unique in the New York area.
- The Program is designed to accommodate both full time students and part time students with the courses being offered in the late afternoon or evening.

The Program as it is now constituted is described in Table I which lists the core courses and the grouping of interdisciplinary courses available to the student. Table II provide a summary description of the content of the core courses. The students, who have undergraduate degrees in a range of engineering disciplines, are required to take a graduate mathematics course, a minimum of four courses from the six available core courses, two additional related courses in mechanical engineering, and up to three courses from the interdisciplinary grouping. The full Program was initiated in the fall 1990 semester with offerings of two core courses and sufficient others from the Table I listing to constitute at least a 12 credit program for full time students. In the spring 1991 semester the Program at Manhattan College offered two additional core courses. In addition, the Program was introduced at the New York Power Authority training facility at Indian Point 3 with one core course being taught this semester. It is our intention to expand the Program at both the College and Indian Point locations to accommodate student interest.

#### Internship Program

An internship program has been established between Dames & Moore and the College for graduate students in the Waste Management/Facility Restoration Program. The

**TABLE I**  
**Waste Management/Facility Restoration Program**  
**Required Course**  
**Graduate Mathematics**  
**&**  
**Core Courses**  
**(Minimum of Four Required)**

- Fundamentals of Nuclear Engineering
- Nuclear Power Systems
- Radioactive and Hazardous Waste Management
- Regulation and Licensing of Nuclear/Waste Management Facilities
- Health and Safety Programs for Remedial Site Workers
- Nuclear Engineering Laboratory
- Field Sampling and Investigation of Contaminated Sites
- Remediation of Contaminated Sites

**TWO ADDITIONAL COURSES WITHIN THE M. E. DEPARTMENT**  
**&**  
**UP TO THREE INTERDISCIPLINARY COURSES FROM**

- Mathematical Modeling I & II
- Principles of Water & Hazardous Waste Water Treatment I & II
- Analysis of Natural Water Systems I & II
- Toxics in Surface and Ground Waters
- Air Pollution Control
- Accident and Emergency Management
- Hazardous Waste Incineration
- Engineering Geology
- Hydrology
- Robotics and Automation
- Analysis and Design of Robotic Manipulators
- Thesis

**TABLE II**  
Core Course Content

- **Fundamentals of Nuclear Engineering:**  
Review of nuclear physics. Transport theory, reactor kinetics, nuclear reactor theory, interaction of radiation with matter, standards of radiation protection; reactor types and characteristics.
- **Nuclear Power Systems:**  
Design and analysis of nuclear power components such as reactor turbines, valves and piping, effluent controls, radwaste systems; transient and steady state heat transfer and fluid flow analysis in nuclear systems; power plant licensing process.
- **Radioactive and Hazardous Waste Management:**  
Engineering, environmental and regulatory aspects of waste management from generation through disposal; waste forms, licensing and compliance; federal programs; facility siting, operation, and closure; impacts, technology of waste management and disposal; remediation of contaminated sites; current case studies.
- **Regulation and Licensing of Nuclear/Waste Management Facilities:**  
Analysis of Federal and State compliance and Licensing processes, regulatory organizations, and responsibilities. Technical inputs, computations, and field programs needed to develop Remedial Investigation/Feasibility Study (RI/FS), and Safety Analysis Report (SAR). Programmatic requirements of waste management laws (RCRA, CERCLA, Nuclear Waste Management Acts) and relevant nuclear laws and regulations (Atomic Energy Act; 10CFR).
- **Health and Safety Programs at Remedial Sites:**  
Fundamentals of health physics and industrial hygiene; occupational and environmental protection standards and procedures; instrumentation; monitoring; protective clothing and equipment; emergency response; documentation.
- **Nuclear Engineering Laboratory:**  
Experiments on basic radiation detection and measurements; measurements of parameters of subcritical and critical reactors; operation of critical reactor.
- **Field Sampling and Investigation of Contaminated Sites:**  
A study of the process of identifying and characterizing contaminated sites as a basis for remediation. Topics include sampling procedures, equipment, CLP laboratory analysis, QA/QC, NRC & EPA requirements, statistical analysis.
- **Remediation of Contaminated Sites:**  
Remedial and disposal alternatives; treatment and conditioning technologies; disposal units; NRC & EPA cleanup and health standards; case studies.

internship program is a significant component of the training of these students.

The cooperative Dames & Moore - College internship program is designed to provide full time graduate students in the Program with the opportunity to gain practical working experience in the field while conducting their graduate studies. The complementary nature of this arrangement gives the student a unique working experience which enhances the value of their course work while providing Dames & Moore with a cadre of junior technical personnel to support the work of the staff professionals. The features of the Program are:

- Full time graduate students in the Program are assigned tasks under the guidance of designated D & M professionals in technical areas related to their course of studies. Students are available for these assignments up to 20 hours/week during the school year, and full time during the summer.
- The material in the graduate courses is specifically tailored to provide the interns with the analytic tools and field capabilities necessary to perform their intern assignments. Faculty are available to provide guidance in performing these assignments.
- Interns perform their assignments either at Dames & Moore's Pearl River offices or at Manhattan College depending on the nature of the tasks. Computer and laboratory facilities at the College are available for use by the interns in performing their assignments.

Internship programs will be established with other firms in the New York area.

#### Physical Resources

The Program benefits from the availability of extensive laboratory, library and computer facilities within the participating engineering Departments. These include nuclear, environmental, civil and chemical engineering laboratories.

The Mechanical Engineering Department operates the Nuclear Laboratory which contains the Manhattan College Zero Power Reactor (MCZPR) and two subcritical reactors. The MCZPR is the only licensed research reactor in the New York metropolitan area. It is an AMF pool type reactor, containing 16 cylindrical fuel elements and producing a maximum output of 0.1 watt. The original high enriched uranium fuel elements have recently been replaced by low enriched uranium fuel. The subcritical reactors are a graphite pile and a water moderated facility. The Laboratory also has a multi-channel analyzer, portable monitoring equipment, and a counting room containing measuring instruments. The resources of the laboratory are used for instruction in conjunction with the undergraduate and graduate nuclear engineering courses, and provide the opportunity for research and training. The facility has been used in

the past for initial training of operators by nearby nuclear utilities to supplement simulator training. Under the sponsorship of a DOE grant, the College is also making the reactor facilities available for demonstration and instruction for students from other colleges and high schools in the area.

Additional facilities of the Mechanical Engineering Department available for use in the Program include a Robotic test facility for research into remote handling and a machine shop for fabricating components for experimental set ups.

The Environmental Engineering and Science Laboratories include a well equipped water, toxic, and wastewater laboratory; a unit operations laboratory for physical, chemical, and biological testing; a micro-biological preparation facility; and a radiological sample preparation and analysis facility. These facilities permit advanced research into contaminant migration in ground and surface water and development of treatment technology in addition to complementing course instruction.

The Civil Engineering Department's soil mechanics laboratory, and the Chemical Engineering Department's Materials and Advanced Separation Laboratories also provide students in the Program the opportunity to conduct research and see relevant principles demonstrated.

#### Personnel Resources

A combination of full-time and adjunct faculty are involved in presenting the core and interdisciplinary courses required for the Program. This mix benefits the students by providing instructors who have had the opportunity to refine the presentation of complex technical subjects and who are available to provide guidance on questions related to resources throughout the College useful in completing a strong graduate program. In addition, the students have access to individuals who are involved in a day to day extension and practical application of theoretical techniques in their professional careers.

The initial core course offerings in the concentration are being presented by two full-time and two adjunct faculty members. The interdisciplinary curriculum, which includes selections from the Environmental, Civil and Chemical Engineering Departments as well as from Mechanical Engineering, is taught by full-time faculty members.

In addition to the faculty members, outside speakers are invited to participate in a number of the courses to address specific topics with which they are particularly familiar. Such speakers may include for example, regulatory personnel, remedial site workers or managers, and emergency response personnel. Their presentations, frequently supplemented by visual aides (slides or videotapes) of actual field operations, provide direct knowledge of the stan-

dard practices, the limitations often imposed by field conditions, and solutions that have been used for remediation of specific sites. As expected, these presentations are particularly well received by the students since they convey a great deal of information in a very concrete manner.

#### **Promotion Of The Program**

An important part of the establishing a successful academic program is to let as many eligible people as possible know that it exists and what it has to offer. The faculty and administration responsible for the Facility Restoration/Waste Management Program have used a variety of methods for spreading the word to potential students.

These include visiting with corporations and groups in the New York metropolitan region who are likely to require the services of people with this background, such as utilities, consulting engineers, environmental restoration firms, and regulatory agencies. The visits serve a dual purpose: they make potential employers aware of an important pool of talent previously unavailable to them as well as a resource for upgrading the training of current employees. Interest has been strong in both these areas. The agreement with the New York Power Authority to conduct classes at the Training Center at Indian Point 3 is an example of the commitment of one firm to make this program as accessible as possible to interested employees.

A more traditional, and very potent portion of the effort to publicize the existence of the program is through contacts with alumni. As was the case with the corporation contacts, alumni may be potential students for the graduate program, they may pass the information along to friends and colleagues, or they may encourage subordinates to consider pursuing further studies, often through existing company tuition reimbursement programs.

The professional affiliations of the members of the faculty have also been useful conduits for distributing information about the program. In particular, close contact is

maintained with the local section (Metropolitan New York) of the American Nuclear Society. This includes meeting with section officers, participating in programs and special events, and including information in the Section newsletter. In one upcoming cooperative program, high school winners of a section essay contest (and their teachers) will be able to tour the nuclear reactor facility at Manhattan College. The benefit to the College and the program is the exposure both to potential students as well as the people who influence many of their choices of careers and colleges. Similar "fringe" benefits are expected from the facility sharing programs that the College is in the process of establishing under the DOE grant.

#### **Response To The Program**

As described in the preceding, the response to the Program offerings has been excellent. After one full semester the Program has 3 full time and 13 part time students enrolled in courses at the College and 24 part time students at Indian Point. In addition there are 9 part time students at Indian Point without the appropriate undergraduate degree who are taking prerequisite courses to permit them to be enrolled in the graduate Program. Numerous inquiries have been received to enroll in the Program in September 1991. The first degree in the concentration will be awarded in May, 1991.

Interest among regional firms in participating in the internship program continues to grow and additional internship arrangements are anticipated in the near term. Substantial interest has also been expressed in hiring our graduates as they become available.

We believe that the Nuclear Waste Management/Facility Restoration Program at Manhattan College provides a unique response to a critical need for trained professionals in the field. We intend to devote necessary resources to the Program to assure its long term success.