

## A NATIONAL ENVIRONMENTAL DESIGN CONTEST AND CAPSTONE COURSE FOR UNIVERSITIES

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### ABSTRACT

The Waste-management Education & Research Consortium (WERC) of New Mexico has developed and implemented an environmental design contest for competition by universities throughout America. This is the first university environmental design contest anywhere in the world. WERC is a consortium of three universities, a community college, and two national laboratories sponsored by the DOE with the mission of generating resources to address issues associated with environmental management. The contest was structured to give university student groups from all over America an opportunity to exchange information via a national contest for design, development, and testing of an environmental control process. A practical environmental problem was presented to the competing teams. Each team prepared a total plant design for the solution of the environmental problem. They further prepared a working model to demonstrate each solution on a smaller scale. The design stressed not just the technical solution, but also such factors as economics, risk analysis, regulations, public policy and communications.

The judging was performed by experts from academia, industry and government agencies. The awards were based on the written plant design, the small demonstration, as well as presentations by the competing teams. All the criteria noted above (technical excellence, risk analysis, etc.) were weighted in the judging. Seven universities from throughout the United States competed in the first contest held in April 1991. The program fully accomplished its objective of providing a design challenge as well as providing a medium of exchanging information in the environmental area between various regions of the country. Over twenty universities have signed up to compete in next year's contest. In fact many have used the contest problem as part of their capstone design course.

This paper presents the experiences of the first design contest and the topic for the second year.

### INTRODUCTION AND PURPOSE

In April 1991, a unique and innovative environmental design contest for universities throughout America was conducted as part of the Department of Energy (DOE) sponsored Waste-management Education and Research Consortium (WERC). The WERC program is managed by the New Mexico State University and includes the University of New Mexico, the New Mexico Institute of Mining & Technology, the Navajo Community College in collaboration with Los Alamos and Sandia National Laboratories. Its mission is to enhance the nations resources to address issues related to environmental management. The design contest under the direction of the NMSU Chemical Engineering Department was co-sponsored by several industrial organizations. The contest was structured to give university student groups from all over America an opportunity to exchange information via a national contest for design, development, and testing of an environmental control process. The judging, performed by experts from academia and industry, was based on technical, as well as other criteria (economic, public communications, regulations, etc.) that are important in today's world.

The first year design was focused on a practical environmental problem, namely clean up of contaminated liquid. The liquid for this purpose was a specified amount of water containing four contaminants, one from each major toxic category. The drinkable water requirements were provided as the final effluent specifications. Each participating team prepared and presented a total plant design, as well as a working model to demonstrate the team's solution to the environmen-

tal problem. In order to facilitate the needs of the participating teams, each team worked with a New Mexico State University student host who participated in every phase of this program.

In addition to trophies, the participating teams received cash awards in several categories which exceeded \$5000.

### DESIGN STATEMENT

The first year process selected was a relatively uncomplicated water pollution problem presented to the potential participants in the format of a letter from the company management to an engineer who has recently joined the company. The potential contestants were informed of the design details in late October, 1990.

The engineer was asked to form a group of experts to design, construct, present and demonstrate the pollution control process. The assignment was to design a clean up process for 15000 gal/day and demonstrate its functionality using 5 gallons of contaminated water. The contaminated water as well as the instruments to measure the inlet and output product stream concentrations were furnished by WERC in conjunction with the Soil, Air & Water (SWAT) Lab on the NMSU premises.

The design teams were provided with the following input-output specifications:

### DESIGN SPECIFICATIONS

The design team was to develop and test a cleaning system for contaminated liquids. The full-scale plant design was for a waste stream flow rate of 15000 gallons/day. The liquid for

the demonstration purpose was 5 gallons of water contaminated with four contaminants or any combination with the inlet concentrations of:

Heavy Metals:	Hexavalent Chromium( $\text{Cr}^{+6}$ )	300 ppm
Organic Solvents:	Trichloroethylene (TCE)	100 ppm
	1,2 Dichloroethane (DCE)	50 ppm
Other Contaminants:	Fluoride (F)	25 ppm

The final effluent stream had to satisfy the following criteria:

$\text{Cr}^{+6}$	0.05 ppm
TCE	5 ppb
F	2 ppm
DCE	5 ppb

The water contained all of the listed contaminants.

There was no restriction on the method used to complete the clean up process (e.g. physical, chemical, biochemical/biological, detox, solar, batch or continuous, etc.)

The participating design teams presented the paper design of the full scale design and demonstrate the bench scale process of their choice on the 5 gallon sample on April 18-20, 1991. The date had been selected to coincide with Earth Day (April 20) in order to maximize the importance of the concept. Additionally, each team had prepared and submitted in advance of the competition, a written report for a full scale process using their proposed bench scale concept.

## METHODS

### Participants Identification

Due to the nature of the competition, and the novelty associated with this first year program, the final attendance was limited to seven teams from universities across the United States. These teams were among fifty plus potential universities from U.S., Canada, and Mexico that had indicated an interest in participating in the competition. The final list of participating teams were as follows:

Arizona State University  
New Mexico Institute of Mining and Technology  
New Mexico State University  
State University of New York at Buffalo  
University of Maryland  
University of New Mexico  
University of West Virginia

### Program Details

The contest participants began arriving at El Paso airport on Wednesday, April 17, 1991. They were greeted at the airport by one of the WERC people responsible for equipment transportation to and from Las Cruces, New Mexico. The contestants were further greeted at the WERC office in Las Cruces by the CEO, Director of WERC, Program Director, WERC staff, and local "student help".

Each participating team was provided with a pre-determined 10' x 10' booth, fully equipped with water, electricity, air and other utilities for the bench-scale tests. The booths were set up on the Bromilow Mall, located on the NMSU campus, with triangular shaped cloth panels separating the booths and tables.

The participating teams received samples for their "test run" on Thursday, April 18, 1991. The program started Friday morning with a brief welcome for all participating teams. Upon completion, a drawing was held to determine the order of the paper presentation by each university. At 9:30 A.M., each team received five gallons of pre-tested sample for treatment in their specific bench scale process. Following the treatment, two different samples from each team's effluent were collected between and were forwarded to the lab for analysis.

**Paper Presentation:** In order to provide enough time to the judges to critically review each paper design, the contestants had submitted their proposed full scale design two weeks prior to the competition date. A very detailed evaluation sheet was provided to the individual judges for this purpose. The submitted reports showed process design, engineering basis for the design, the economics of the selected process, discussion of the legal implications, and a plan for presentation to the community in order to minimize potential negative public reaction.

On Friday, April 19, 1991, the contestants were allotted 15 minutes each to present their papers to the judges and other public audience. The judges had time for rigorous questioning of the team members on issues related to technical, economics, legal implications, process selection, and others. The public audience was also provided with an opportunity to ask questions of the team presenting their process.

**Experimental Demonstration:** The judges were provided two hours on Saturday morning to inspect each teams bench scale demonstration. They questioned the team members on all areas of design and construction and evaluated them on a variety of factors such as yield, operating and capital costs, esthetics, functionality, unit operation and others.

The laboratory samples taken on the previous day identified the performance of each team in meeting the specifications for removal of the contaminants and played an important role in the judges decisions for the final outcome.

**Evaluations:** At the conclusion of the contest the participants were given evaluation forms to complete. These forms attempted to evaluate:

1. Overall quality
2. Length and content of the competition
3. Strength and weakness of the competition

The comments were very favorable. The competing teams provided some positive feedback and enhancements for the future competitions.

**Publicity and Sponsorship:** Pre-contest publicity was obtained through several press releases, as well as interviews by local representatives of newspapers and television. Additional publicity was received by inviting the local media to participate, record, and broadcast live on the progress of the competition and the final outcome of it. The design contest was conducted by the DOE WERC program. However, financial support was fully provided by the industrial sponsors.

## RESULTS AND CONCLUSIONS

The seven participating design teams competed in a two day event containing the paper design and presentation as well as the bench scale demonstration of their selected processes for removal of the specified contaminants from 5 gallons of water. Using different unit operations, each team managed to obtain a varying degree of success on the desired results.

Each of the participating team received a trophy made from WIPP site core samples that were mounted on wood bases. The WERC logo was mounted on top of the sample and a brass plaque was mounted in front of the core sample to the wood base indicating the placement of the award recipients.

As stated by the critique sheets of the participants, they undoubtedly found the competition challenging, well organized, and worthwhile. They found this event to be educational, rewarding, and extremely valuable. Some of the participants expressed a desire for longer lead time and longer length of actual competition in order to separate, and hence, be able to

attend both the paper presentation and the demonstration events.

### Future Plans

The Second Annual Environmental Design Contest is to be held in Las Cruces, New Mexico on April 15-18, 1992 and will focus on a unique and realistic soil contamination problem. The participating teams are to design, develop, test, and demonstrate their remediation system for cleanup of a sandy loam textured soil containing a combination of five contaminants. The contaminants are organically bound lead, hexavalent chromium, diesel fuel, trichloroethylene, and radioactive surrogate. For the Second Annual Environmental Design Contest, the number of participating teams as well as the cash awards are at least triple that of the first year competition.

In the future, the contest will be held at different sites with the possibility of several contest in a given year held regionally.