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Hydrologic Engineering Center

Twenty-Five Years of Developing, Distributing, and Supporting Hydrologic Engineering Computer Programs

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Papers in this series have resulted from technical activities of the Hydrologic Engineering Center. Versions of some of these have been published in technical journals or in conference proceedings. The purpose of this series is to make the information available for use in the Center's training program and for distribution with the Corps of Engineers.

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TWENTY-FIVE YEARS OF DEVELOPING, DISTRIBUTING, AND SUPPORTING HYDROLOGIC ENGINEERING COMPUTER PROGRAMS[a]

Darryl W. Davis, P.E.[1] and Vernon R. Bonner, P.E.[2]

ABSTRACT: The Hydrologic Engineering Center (HEC) performs research and provides training and technical assistance for the development, deployment, and support of hydrologic engineering methods for Corps field office use. We understood early that to successfully accomplish the task, we needed to evolve a process that would place a family of high quality computer programs in the hands of users and assure that they would be effectively used. Several single purpose programs were released in 1964 and our first major computer program releases were made in 1968. The programs were made available in source code form on punched cards, and were accompanied by user's manuals, source code compilation instructions, and test data sets. The user was offered applications training, direct phone/on-site assistance, and the opportunity to join a network of users. This same philosophy is applied today. Our computer program products are substantially more capable (and complicated) and are in use by a wider variety of professionals in a more diverse computer hardware and operating system environment. The service and support functions, however, are more diffused. This paper presents an overview of the software development, distribution, and support experience of the Hydrologic Engineering Center. Comments are made regarding the future role of HEC and others in the distribution and support of HEC programs.
KEY TERMS: Computer programs, software support, user documentation.

INTRODUCTION

The Hydrologic Engineering Center was established in 1964 to provide technical services to Corps offices engaged in Civil Works activities. The technical areas of responsibility are hydrologic engineering and planning analysis techniques closely associated with hydrologic engineering. Within these technical areas, HEC provides services in research, training, and technical assistance. The Center has a staff of 25 professional engineers and computer scientists working in the executive office or the research, training, planning analysis, or technical assistance divisions. Support staff and a complement of 5 to 10 graduate students in water resources from the nearby University of California campus complete the staff.

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Applied research is designed to develop systematic methods that can save time and increase the effectiveness of experienced professionals and also enable less experienced persons to perform their duties with minimum start-up time. The products of these efforts are primarily general purpose computer programs and companion user's instructions and study methods guides. HEC distributes and services about 100 computer programs for application in hydrologic engineering and planning analysis (Corps of Engineers 1989). Table 1 summarizes information about the computer programs in the HEC library.

Table 1
Hydrologic Engineering Center
Software Library

Program Category	Major Programs	Other Programs	Editors/ Utilities	Total Programs	Implemented for PC's
Surface Water Hydrology	3	7	-	10	3
River Hydraulics	2	3	10	15	11
Reservoirs	1	4	5	10	5
Statistical Hydrology	1	5	-	6	3
Planning Analysis	3	6	1	10	7
Water Quality	2	4	1	7	4
Data Storage System	2	1	11	14	8
Water Control	-	3	14	17	-
Miscellaneous	2	1	4	7	2
Totals	16	34	46	96	43

Training is directed toward reducing the time needed for entry level professionals to become proficient in technical analysis and to familiarize seasoned professionals with new developments. The majority of the training is devoted to teaching effective use of HEC developed computer programs. About 500 student-weeks of training in a dozen courses are conducted annually. About two-thirds of the courses are hydrologic engineering courses and the remainder are planning analysis courses.

HEC works with Corps field offices in the application of new or unfamiliar procedures and in the solution of particularly complex and

difficult water resources problems. The technical assistance projects begin with a negotiated reimbursable agreement and typically involve staff of the field office working with staff of HEC. The projects normally conclude with a joint product that solves the field office problem in a way that further assistance from HEC is not needed. The products often provide the basis for an improved general purpose solution that can be further developed with research funding into a product usable by the Corps as a whole.

PROGRAM LIBRARY AND SUPPORT EVOLUTION

The present computer program library, documentation, and support activities are the cumulative result of three eras of HEC activities. The first decade (1964 -1973) was that of single purpose programs, limited types and numbers of mainframe computer systems, and direct engineer - program user support activities. The second decade (1974 - 1983) was that of packaged programs, integration of data management systems, mini/mainframe computers and an expanded user community. The 1984 - 1990 period is that of the personal computer (PC) characterized by many machines, greatly expanded user community, increased attention to user interface and graphics, and diffused program distribution and support.

The First 10 Years (1964 - 1973)

The program development efforts were directed initially to computerizing existing analysis methods documented in Corps Engineer Manuals. The first group of programs released were single purpose, limited scope programs. Separate programs were developed for unit hydrograph computations, basin rainfall excess determination, stream flow routing, and similar functions/purposes. Subsequently, the small single purpose programs were integrated into more complete program packages, represented by such programs as HEC-1 "Flood Hydrograph Package" (Corps of Engineers 1970), HEC-2 "Water Surface Profiles" (Corps of Engineers 1966), and HEC-3 "Reservoir System Analysis" (Corps of Engineers 1971). Input was on punched cards and output was numerical/text with graphics represented as line printer plots. Output could be obtained in punched card format for subsequent input to other analysis programs. User documentation ranged from a limited user's manual (typically less than 10 pages, most of which was a detailed input variable description) for single purpose programs to larger (50 pages or more) for the few major programs. Occasionally short handout papers of a few pages, developed for training courses, were available. Programmer's manuals were developed for a few major programs. An example is the HEC-1 Programmer's Manual (Corps of Engineers 1973). Reference was made to existing Corps technical manuals, mostly dated in the mid- to late 1950's, for technical details about program computations. Incidentally, these technical manuals are just now (1990) in the process of being revised and updated.

Early in this period, computer hardware consisted of IBM 650 and 1620 class machines. Later IBM 7090 class machines became the norm. Programs were distributed as FORTRAN source code in punched card

format. Users needed only to be concerned with applications while systems professionals dealt with hardware/operating system issues.

This period was characterized by the concept of an HEC engineer/programmer assigned for each program. The user community was modest from the standpoint that user support was not overly burdensome for HEC staff. High quality user's manuals, direct telephone support for all users, training courses, and systematic computer program maintenance emerged as important and well established principles for assuring effective and efficient use of the program library. The 1973 Annual Report (Corps of Engineers 1973) includes a listing of 28 computer programs presented as available from and supported by HEC. Six of these programs are classified as major including flood runoff, river hydraulics, reservoir systems, and statistical analysis. The remainder are more limited scope, special purpose or minor programs. Fifteen of the 28 programs continue to be maintained in the 1990 HEC program library.

The Second 10 Years (1974 - 1983)

Program development efforts during this period emphasized creating a specialized hydrologic engineering data management system, integrating it with existing programs, and expanding the technical areas addressed by the programs. Major program additions included the HECDSS system (data management), beginning of the real-time water control software family, HEC-5 (reservoir system analysis for flood control and conservation), a package of flood damage analysis programs, and a family of graphics, utilities, and data communications software. Punched cards, (and punched card machines) disappeared from HEC. Data entry was now via remote terminal (creating data files) and output generally went to line printers. Graphics became more important. User documentation became substantially more sophisticated and complete. User's manuals were expanded. A typical manual now comprised near 100 pages including technical descriptions, input preparation assistance, and illustrated examples. Companion applications documents (training documents) were developed for most major programs.

The hardware of this period is typified by a CDC Cyber computer with substantial computing power accessed through inexpensive graphic terminals. Late in this period, most Corps offices installed Harris 500 or 1000 machines - very capable minicomputers. These became a mainstay of the hydrologic engineering community. Within the Corps, programs for the Harris computers were distributed on a mail-out tape containing executable code. This greatly simplified program distribution for ourselves as well as the using offices. For non-Harris sites, programs were distributed as FORTRAN source code via magnetic tape. The programs were accompanied by compilation instructions and test data. With the advent of the HECDSS software, increasingly capable graphics packages, and data communications packages, we had to concern ourselves with the specific hardware and operating system environments in which the programs would be used. These added complications were not welcomed.

The user base for HEC programs was greatly expanded with the wide-spread application of HEC computer programs, particularly HEC-2, in support of the National Flood Insurance program. The daily use of these programs expanded several fold in a matter of two years. The concept of the HEC engineer/programmer assigned for each program became stressed with the advent of a greatly enlarged community of users expecting support. We continued to provide HEC computer program hot-line support to all program users regardless of their affiliation. Training courses were restricted to Corps staff with openings, as available, filled on a first come, first served basis. We presented several classes for private consultants to support our field offices contracting out for flood insurance studies.

The 1983 Annual Report (Corps of Engineers 1983) includes a listing of 66 computer programs presented as available from (a few restricted to Corps offices only) and supported by HEC. Five new major programs were added for a total of 11. Two of these were in the HECDSS data management area and the others were in water quality, statistical analysis and flood damage analysis. The remaining 55 (17 from the first 10 years) are limited scope, special purpose, or minor programs. They span the range from graphics, specialized editors and analysis utilities, but also include limited applications water quality, hydroelectric power, hydraulic and hydrologic analysis programs. Thirty-seven of the 66 programs continue to be maintained in the 1990 HEC program library.

The Personal Computer Era (1984 - present)

HEC released its first personal computer version of an HEC program in 1984. The program was HEC-2. Our business has not been the same since. The number of users expanded several orders of magnitude, and we were nearly overwhelmed with user calls for assistance. Our focus of necessity turned to the user interface, interactive graphics, and preoccupation with operating system details here-to-fore outside the realm of our concern. We ended up explaining MS-DOS to new PC users.

Significant efforts have been devoted to moving existing programs to the PC environment. Forty-three of the 96 programs in our present program library are available in PC versions. We have developed only one new program designed specifically for the PC environment. Another new program (that is considered a major product) is nearing release that is designed specifically for the PC/workstation environment.

We enhanced and released our own text editor to better meet our program development and data entry needs; built menu shells for file, program execution, and display management for our major packages; and became far more expert in the intricacies of the PC than we expected (or hoped) would be needed. We found that user instructions for program application were no longer sufficient. Many users both inside and outside the Corps were just developing PC literacy and therefore needed program installation guides, PC file management standards, and similar information. We needed to handle the explosion of output devices (device drivers), and a multitude of other non-technical items. Without question, our programs were made more useable and

widely available but the price was distraction from continued development of new technical products.

We experienced increased non-Corps requests for training course attendance, tapes of course lectures, and course materials. Also occurring at this time were increased offerings of HEC based short courses through university extension programs. A budding private vendor industry for marketing PC based engineering programs also surfaced. After much internal deliberation and several false starts, HEC adopted and published in the public record, a policy of encouraging private vendor distribution and support for HEC programs to non-federal parties. This became effective October 1988. Requestors for programs, training and similar services are referred to a vendor list that is maintained for that purpose. Several thousand HEC program copies have been successfully and professionally provided to the public by the vendor community.

We did not completely ignore mainframe applications. The family of computer programs to support water control (daily operations of existing Corps reservoir projects) was significantly expanded. These programs are supported for the Harris systems dedicated to water control activities within the Corps. Technical features of programs were updated for mainframe versions simultaneously with the intensive PC applications activities. Notable were major additions to HEC-1 (Muskingum-Cunge routing and kinematic wave surface runoff transform), HEC-2 (culvert hydraulics and hydraulic design capabilities), and HEC-5 (power operation algorithms). A few new programs were developed in the traditional batch style. Table 1 summarizes the programs in the 1990 HEC program library. The recent annual report (Corps of Engineers 1989) tabulates the 96 programs shown in Table 1.

HEC PROGRAMS AND SUPPORT IN THE NEXT DECADE

We have (or soon will) have all our major programs assembled into similar PC packages. Program documentation has been updated and upgraded (thanks to today's word processors). Several new training documents provide details on the PC packages and special program applications. We are envisioning this set of releases to be our last major PC (batch programs ported) releases. University short courses and private vendors appear to meet much of the non-federal needs for PC programs distribution, training, and technical support. We now plan to focus on the future.

We view the coming decade (1991 - 2000) as that of the engineering workstation. These machines are very computationally powerful, have exceptional graphic display capability, and will be networked to share mass storage, output devices, and computational resources. The next five years are expected to see transition from DOS to these UNIX based systems. About mid-decade, we anticipate about half of the Corps will use HEC programs on these systems. We are embarked on an intensive developmental effort that will yield successor program packages to the existing major programs. Under development are packages we refer to as the river analysis system, the catchment analysis system, the reservoir analysis system, and the

flood damage analysis system. These systems of programs are being developed specifically for the UNIX workstation environment. The program systems will feature new computational algorithms, incorporate imaging and geographic information system capability, and will be executed within an interactive graphic user interface. Computational features of existing programs may be incorporated as proves to be desirable.

The multi-tasking, multi-user, exceptional graphic features of UNIX workstations are compelling in support of engineering applications. We are hopeful that DOS and UNIX will rapidly merge to more common attributes over the coming years so we do not have to maintain significantly different code to service both groups of users. By mid-decade we expect to service the Corps (in the priority listed) software for: UNIX workstation, DOS PC, and Corps mainframe (probably CDC Cyber).

We are committed to the current policy of private vendor distribution and support of HEC programs for non-federal users. We will encourage and support expanded training offerings by vendors and universities. New program development will be emphasized through in-house efforts and increasingly through contract assistance from the private sector. We expect the coming decade to be busy, exciting, and most gratifying in continuing our historical role of developing and servicing a wide array of hydrologic engineering and planning analysis computer programs.

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