Journal of Coastal Research	10	2	270–277	Fort Lauderdale, Florida	Spring 1994

Regional Coastal Databases for Corps of Engineers Districts

Danielle S. McAneny

Coastal Engineering Research Center
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180, U.S.A.

ABSTRACT

McANENY, D.S., 1994. Regional coastal databases for Corps of Engineers districts. *Journal of Coastal Research*, 10(2), 270–277. Fort Lauderdale (Florida), ISSN 0749-0208.

From a mainframe computer version in the early 1980's to today's microcomputer format, coastal databases have been recognized as important tools for support of Corps of Engineers coastal projects. The Coastal Engineering Data Retrieval System (CEDRS) takes advantage of the microcomputer environment to provide convenient access to the voluminous oceanographic datasets. CEDRS uses a regional approach, generally following Corps of Engineers District boundaries, to allow its systems to operate in the microcomputer environment using relational database techniques, and to contain a comprehensive long-term set of both hindcast and measured wind and wave data for the use of Corps coastal engineers and scientists. This presentation of the pitfalls and problems encountered in design and development of the CEDRS databases may be of benefit to other developers of this type of system.

ADDITIONAL INDEX WORDS: *Coastal Engineering, computer hindcasts, oceanographic datasets, water waves, winds*

INTRODUCTION

In 1978, a computer hindcast project to produce a wave climate for United States coastal waters was initiated (CORSON *et al.*, 1980) at the U.S. Army Engineer Waterways Experiment Station (WES). Under authority of the Office, Chief of Engineers, U.S. Army, and as a function of the Coastal Field Data Collection Program, the Wave Information Study (WIS) group of the WES Hydraulics Division was formed to carry out this work.

The first dataset resulting from this project was a 20-year time series of climatological data for locations along the Atlantic coast of the United States (BROOKS and CORSON, 1984). Additional hindcasts for the Great Lakes, Gulf of Mexico, and Pacific coasts of the United States followed. As Corps engineers and scientists began to use this large dataset for support of projects such as design of coastal structures, study of shoreline erosion, and beach enrichment, the need soon became apparent for a system to allow users direct access to the data.

In 1983, the first coastal database for Corps of Engineers Districts was developed (RAGSDALE, 1983; MCANENY, 1986). The purpose of that database was to provide users direct access to the data produced by the WIS hindcasts. That system, the Sea-State Engineering Analysis System (SEAS), was developed for the computer hardware (Honeywell DPS-8) and data storage media (magnetic tapes) available to WES at that time. SEAS was designed to operate in a combined interactive (time-sharing) and remote batch mode. This mode of operation allowed users the convenience of conversational system interaction for choosing from available data and output products, while the time-consuming processing tasks were performed in the batch environment for efficiency.

The vast quantities of hindcast data were stored on magnetic tape. A single 20-year time series for one location is approximately 60,000 records; and the first WIS hindcast produced data for 73 locations along the Atlantic coast—a total of more than 131 megabytes of data.

Basic operation of SEAS allowed the user to extract a dataset for a chosen location and time period to be copied to disk storage. The user could then choose from a number of plots and statistical procedures to process the data and display results at his terminal.

SEAS was made available to all Corps of Engineers offices via long-distance telephone dial-up to the WES computer. Any Corps user with a terminal and modem was only a telephone call away from the SEAS database on the WES Honeywell computer.

93057 Received 18 May 1993; accepted in revision 6 June 1993.

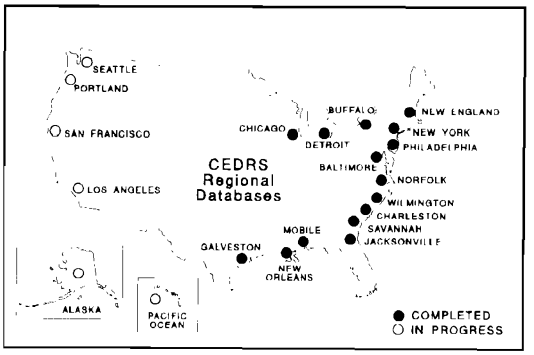

Figure 1. Map showing CEDRS database sites for Corps of Engineers coastal districts.

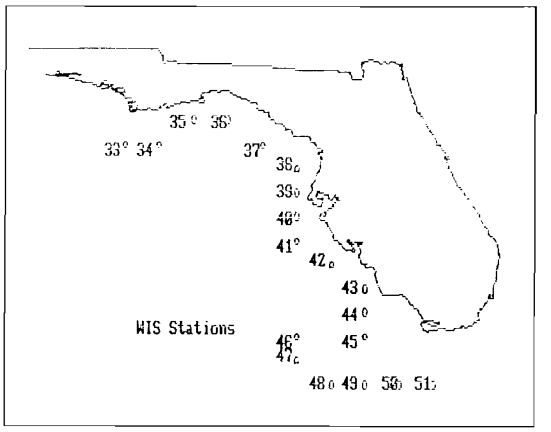

Figure 3. Map showing locations of WIS stations from the 1988 Gulf of Mexico hindcast.

Even though SEAS was a friendly, relatively easy-to-access system, users at remote Corps offices did not make use of the system in large numbers. Many Corps offices had problems with basic system communication via long-distance telephone; but the primary problem with SEAS was that most users needed, not data subsets, but entire 20-year datasets to be used as model input. With communications line speeds available at that time, it was not practical to transmit an entire 60,000-line dataset to a remote office. Most users preferred to have their SEAS processing done at WES and final output mailed to them, rather than contending with the frustrations of communications and datasets too large for transmission. For a number of years, SEAS served as one of the primary data-distribution media for WIS hindcast data; the only alternative was shipment of magnetic tapes to requesting users.

```
Coastal Engineering Data Retrieval System
CEDRS

MASTER MENU

1. Regional Map
2. Available Information for Region
3. Extract of Data Subjects
4. Plot Data
5. Precomputed Statistical Reports
6. Hurricane Statistics
7. Exit to DOS

   0 = HELP    SELECT (0 or 1 - 7)  [1]
```

Figure 2. CEDRS Master Menu showing basic system functions.

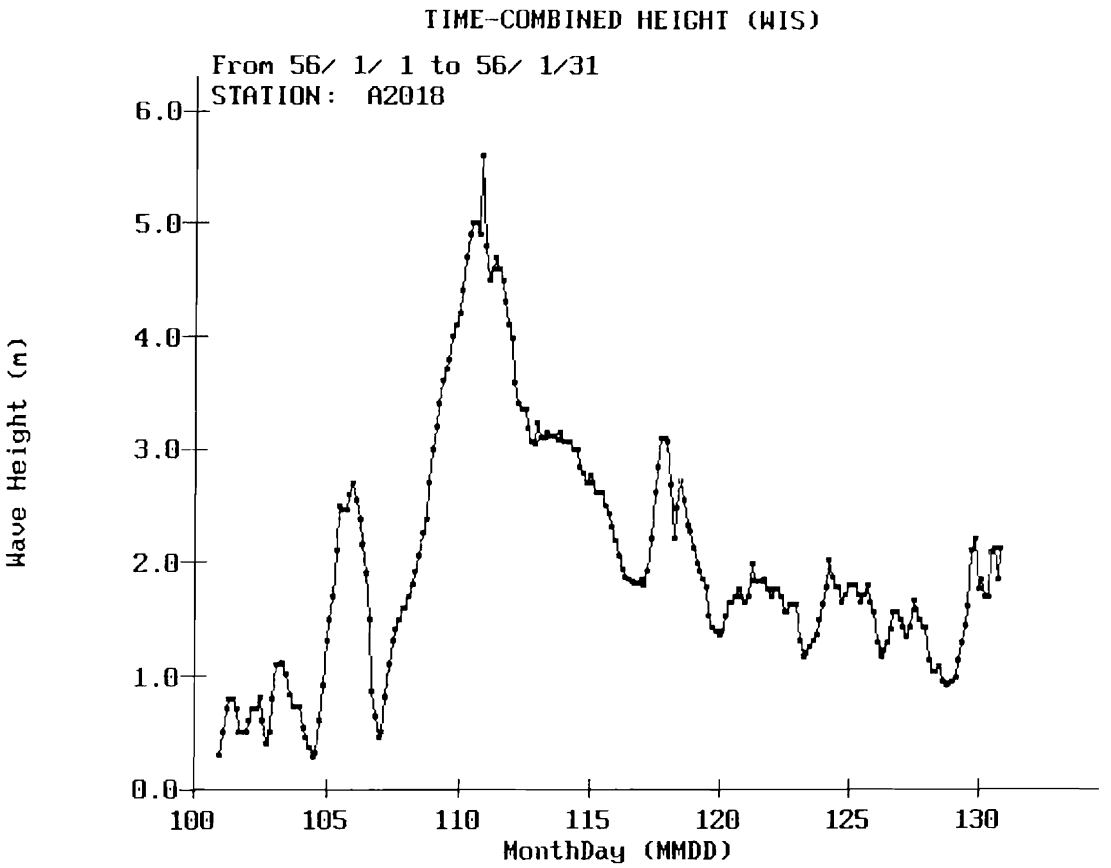

Figure 4. Plot of WIS wave height for Atlantic Station 18 for the month of January 1956.

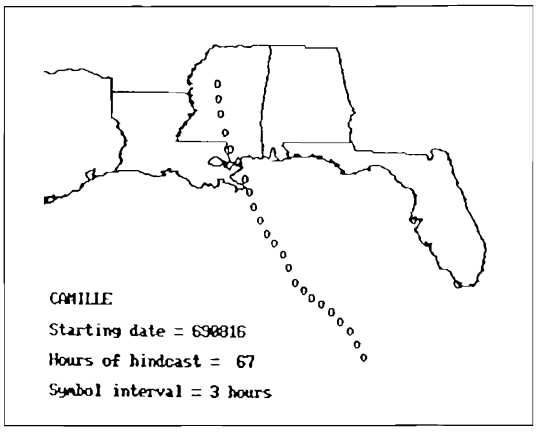

Figure 5. Map depicting storm track of 1969 Hurricane Camille.

REGIONAL DATABASE CONCEPT

In the late 1980's, with the popularity of microcomputers (PC's) growing in Corps offices, a new means of distributing data was envisioned—a microcomputer database conveniently located in the engineer's office. From this vision, the Coastal Engineering Data Retrieval System (CEDRS) was born—an interactive microcomputer-resident database system to provide not only hindcast data, but also measured wind and wave data, for use in the field of coastal engineering. CEDRS was designed from a regional approach to allow handling of the massive amount of available data in the microcomputer environment; a total of 21 CEDRS database sites were defined (Figure 1) for regions approximately following the boundaries of coastal Corps of Engineers Districts.

STATION A2028 (30.75N, 81.25W) DEPTH: 11 Meters

	RETURN PERIOD (Years)					
	2	5	10	20	25	50
TYPE I	3.52	3.81	4.01	4.20	4.26	4.44
TYPE II	3.54	3.87	4.12	4.38	4.47	4.74

NOTE: Return periods calculated using ACES code for Extremal Significant Wave Height Analysis--Goda Method, Fisher-Tippett Type I and II probability distributions. (Leenknecht, 1990).

Figure 6. Example of statistical table showing Return Period of extremal wave heights for WIS hindcast data.

CEDRS PILOT SYSTEM

In 1989, a pilot version of CEDRS was developed for the Gulf of Mexico coast of Florida for the Jacksonville District. This initial system was composed of an interactive FORTRAN module and a series of data files, stored in ASCII format, containing:

19 WIS hindcast stations,
2 University of Florida Coastal Data Network stations,
1 Littoral Environment Observation Retrieval System (LEO) stations, and
2 National Data Buoy Center (NDBC) stations.

A number of references are provided in the Bibliography at the end of this article which give detailed descriptions of all of the data types included in CEDRS, their sources, and their method of collection (or computer generation).

The system was stored on an external optical disk drive connected to one of the District's standard AT-type microcomputers. The storage medium used was an IBM 3363 optical disk drive with 200-megabyte removable cartridges. One of these cartridges provided adequate space for data-storage requirements with additional space for growth.

Basic CEDRS functions are shown in Figure 2, a replica of the CEDRS Master Menu. Figure 3 shows one of the regional maps, which in conjunction with tables of location data are used for defining available data. An example of one of the various types of data plots is shown in Figure 4. Figure 5 illustrates one of the hurricane products; and Figures 6 and 7 illustrate several of the CEDRS statistical tables. Probably the most important CEDRS function allows extraction of user-defined data subsets for import into other software modules (*i.e.*, spreadsheets, graphics, and various Corps engineering models). Figure 8 describes the contents of a typical CEDRS extract file for WIS hindcast data.

The pilot CEDRS system was well received by District users, even though data access was relatively slow by today's standards. Availability of this comprehensive dataset in the engineer's office was a major improvement in data accessibility.

Data-access speed in the pilot CEDRS system was restricted not only by the slow access time of the optical-disk hardware, but also by the sequential structure of the data files. With sequential files, every record must be read until the desired record is reached. Measured data sets were not large enough to cause significant data-access delays; but for the WIS hindcast data, even though subdivided into 20 yearly files, read time for records near the end of a yearly file was quite lengthy.

INTRODUCTION OF RDBMS TECHNIQUES

Investigation of alternative data-storage techniques was the obvious next step. Since Relational DataBase Management System (RDBMS) techniques seemed to offer the most potential for speeding up data access, a study was made of RDBMS software available for the microcomputer environment. We were aware that the CEDRS data did not need the relational capabilities of this technique, but hoped that increased speed of data access would offset any disadvantage produced by the overhead introduced by the RDBMS technique. After months of study and software testing, an RDBMS software package was chosen for CEDRS which met our requirements:

(a) Availability of Structured Query Language (SQL) access to allow the CEDRS database to be directly accessible by users outside of CEDRS. This was an important factor since a major CEDRS

PERCENT OCCURRENCE (X1000) OF HEIGHT AND PERIOD
FOR ALL DIRECTIONS

STATION: A2001 (24.5N, 81.2W / 183.0M) NO. CASES: 58440
% OF TOTAL: 100.0

HEIGHT IN METERS	PEAK PERIOD (IN SECONDS) <4.0	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00-0.99	41457	26806	7790	492	313	343	362	251	207	270	78291
1.00-1.99	.	4199	5821	6160	2770	480	6	.	.	.	19436
2.00-2.99	.	.	27	138	817	800	246	47	1	.	2076
3.00-3.99	.	.	.	.	6	51	87	20	3	.	167
4.00-4.99	.	.	.	.	.	3	10	.	.	.	13
5.00-5.99	.	.	.	.	.	.	.	.	.	.	0
6.00-6.99	.	.	.	.	.	.	.	.	.	.	0
7.00-7.99	.	.	.	.	.	.	.	.	.	.	0
8.00-8.99	.	.	.	.	.	.	.	.	.	.	0
9.00-9.99	.	.	.	.	.	.	.	.	.	.	0
10.00+	.	.	.	.	.	.	.	.	.	.	0
TOTAL	41457	31005	13638	6790	3906	1677	711	318	211	270	

MEAN Hmo(M) = 0.7 LARGEST Hmo(M) = 4.3 MEAN TP(SEC) = 4.1

Figure 7. Excerpt from Percent Occurrence Table showing distribution of wave heights and periods. Separate tables for 16 direction bands and a composite table for all directions are available.

goal was to maintain compatibility with the Automated Coastal Engineering System (ACES), a library of coastal engineering computer programs which require CEDRS data for input (LEENKNECHT and SZUWALSKI, 1992).

(b) Capability of handling large databases. Many of the popular RDBMS software packages marketed for the microcomputer environment are not capable of handling a database of the size needed for CEDRS.

(c) Availability of training and technical support. Since project personnel had no prior training in use of RDBMS techniques, considerable initial training was required. Training classes were readily available in this geographic area; and technical support for other large RDBMS projects was already available on-site at WES.

The RDBMS chosen for CEDRS was ORACLE Corporation's ORACLE for MS-DOS. Their ORACLE Pro-FORTRAN interface was also included to allow more flexibility in design of user interaction functions. CEDRS screens and built-in information files eliminated the requirement for users learning how to use the RDBMS software.

The basic approach to development of a new RDBMS-based CEDRS involved retaining the basic input and output data functions of the FORTRAN-based pilot system, and linking this module to the new ORACLE database via the Pro-FORTRAN interface which converted SQL necessary for accessing the RDBMS database to standard FORTRAN. The reason for choosing this approach was to retain the user-friendly look popular with Corps users of the ACES library (and preserved in the pilot CEDRS system), and eliminate the requirement for learning the RDBMS "language". And, we felt that this approach would simplify system development—we need only to convert the database to RDBMS format and link it to our FORTRAN program module.

Conversion of the pilot CEDRS system to the new RDBMS format proved to be a lengthy and painful process. Even after the basic training suggested for system developers in the use of the RDBMS package, we still faced months of "trial-and-error" in building our new database and linking our FORTRAN module. Most of the training offered for RDBMS system developers was directed toward mainframe computer users, with very little specific training or information available for the microcomputer environment.

The first major obstacle encountered was in use of the optical-disk storage media. After purchase of the ORACLE RDBMS software, months of training, and embarking on initial system development, we discovered that ORACLE did not support use of "write-once" optical-disk media. Obviously, we had not asked all of the right ques-

```
Header line 1 -- Station identification information

  Data type (WIS)
  Station name/number
  Start date (year/month/day/hour)
  End date (year/month/day/hour)
  Total number of records available
  Latitude
  Longitude
  Water depth

Detail lines 2 thru n -- Time series of wind/wave parameters

  Station name/number
  Date/time (year/month/day/hour)
  Spectrally-based significant wave height (Hmo)
  Peak wave period
  Peak wave direction
  Mean wave period
  Mean wave direction
  First wave component (sea) height/period/direction
  Second wave component (swell) height/period/direction
  Wind speed
  Wind direction
```

Figure 8. Typical CEDRS data record contents for WIS hindcast data.

tions to be sure we were getting a system to meet our needs.

To get around this obstacle, we chose a new storage medium—a standard external disk drive with a capacity of 600 megabytes. We chose the much larger 600-megabyte-capacity disk (optical-disk cartridges were 200 megabytes each) because we had already learned from experience that the ORACLE system itself required considerable storage and that our database files were at least 20 percent larger than the ASCII originals with the added overhead of RDBMS indexing.

We chose an external disk drive which used the Small Computer Systems Interface (SCSI), because our investigative efforts seemed to indicate that this type of drive could more easily be added to PC's whose internal disk controllers used other interfaces. This was a fortunate choice which allowed for maximum compatibility with the various PC's provided by Corps offices for installation of the CEDRS systems. Installation on a PC with other than a SCSI interface for its internal hard-disk drives, requires a controller board for interfacing the CEDRS disk drive. PC's with SCSI interfaces for their internal hard disks do not require an added controller board; the PC's internal controller accepts the CEDRS disk as an additional drive.

A multitude of additional general hardware and software incompatibilities plagued our disk installations on the many different brands of computers used for CEDRS systems. We learned to correct conflicting addresses and interrupts as well as how to solve major conflicts with network and other software installed on the CEDRS PC's. Each CEDRS installation provided a new challenge in hardware and software compatibility.

With the beginning of development of CEDRS systems for the Great Lakes, we faced a new problem—much more data was available than for any of the previous CEDRS regions along the Atlantic and Gulf coasts. The Detroit District is responsible for parts of four of the Great Lakes, a total of more than 1,800 megabytes of data in RDBMS format. The largest disk capacity that we could purchase at the time was 1.2 gigabytes (1,200 megabytes)—only about one-half of the capacity we needed. Again we faced a major hardware challenge in attaching multiple disk drives to a single PC. Technical specifications for the disk drives and controllers we were currently using claimed that "daisy chaining" up to seven disks together was possible; *i.e.*, connection of multiple disks to each other with a single controller for all disks. It was possible to do so, but again, not without a great deal of "trial and error". The final solution

to the problem was the addition of a chip to the controller board and an appropriate cable for connecting the PC's.

CONCLUSIONS

At this stage in the life of the CEDRS project—with hardware, software and system design choices firmly in place and more than half of the planned systems installed—our final goal is within sight. Each coastal Corps of Engineers District will have its own regional CEDRS database accessible on a microcomputer.

With today's rapidly advancing computer technology, the vastly more powerful "workstation" is replacing the PC as the computer of choice for many Corps engineers. We again face the challenge of a complete conversion of our system to a new computer environment—an environment not nearly as standardized as that of microcomputers. Already study and testing are underway to provide a much expanded coastal database (*i.e.*, water levels, currents, bathymetry and other parameters required by the more sophisticated computer models now being developed). This next generation of CEDRS will not only target the workstation environment but will take advantage of networking capabilities now commonly available to give Corps engineers and scientists more convenient access to an even larger coastal database to support their project needs.

ACKNOWLEDGEMENTS

The author wishes to thank Doyle L. Jones, system analyst, who shared all of the pain and frustration of CEDRS system design, development, and installation. Thanks are also extended to personnel of the Jacksonville District, Corps of Engineers, for their willingness to serve as the CEDRS pilot installation site.

This work was performed at the Coastal Engineering Research Center of the U.S. Army Engineer Waterways Experiment Station, and was funded by the Coastal Field Data Collection Program, Office of the Chief of Engineers. Permission was granted by the Chief of Engineers to publish this paper. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products by the United States Government.

LITERATURE CITED

BROOKS, R.M. and CORSON, W.D., 1984. *Summary of Archived Atlantic Coast Wave Information Study Pressure, Wind, Wave, and Water Level Data.* WIS Report 13, U.S. Army Engineer Waterways Experiment Station.

CORSON, W.D.; RESIO, D.T., and VINCENT, C.L., 1980. *Wave Information Study for U.S. Coastlines; Report 1: Surface Pressure Field Reconstruction for Wave Hindcasting Purposes.* Technical Report HL-80-11, U.S. Army Engineer Waterways Experiment Station.

MCANENY, D.S., 1986. *SEA-STATE Engineering Analysis System (SEAS), Revised Edition 1.* WIS Report 10, U.S. Army Engineer Waterways Experiment Station.

RAGSDALE, D.S., 1983. *SEA-STATE Engineering Analysis System (SEAS).* WIS Report 10, U.S. Army Engineer Waterways Experiment Station.

APPENDIX A
BIBLIOGRAPHY

ABEL, C.E.; TRACY, B.A.; VINCENT, C.L. and JENSEN, R.E., 1989. *Hurricane Hindcast Methodology and Wave Statistics for Atlantic and Gulf Hurricanes from 1956-1975.* WIS Report 19, U.S. Army Engineer Waterways Experiment Station.

COASTAL DATA INFORMATION PROGRAM (CDIP), MONTHLY REPORTS, January 1976 to December 1992. Monthly Summary Report Nos. 1–201, San Diego: University of California, Scripps Institution of Oceanography.

CORSON, W.D.; ABEL, C.E.; BROOKS, R.M.; FARRAR, P.D.; GROVES, B.J.; PAYNE, J.B.; MCANENY, D.S., and TRACY, B.A., 1987. *Pacific Coast Hindcast Phase II Wave Information.* WIS Report 16, U.S. Army Engineer Waterways Experiment Station.

DRIVER, D.B.; REINHARD, R.D., and HUBERTZ, J.M., 1991. *Hindcast Wave Information for the Great Lakes: Lake Erie.* WIS Report 22, U.S. Army Engineer Waterways Experiment Station.

DRIVER, D.B.; REINHARD, R.D., and HUBERTZ, J.M., 1992. *Hindcast Wave Information for the Great Lakes: Lake Superior.* WIS Report 23, U.S. Army Engineer Waterways Experiment Station.

HUBERTZ, J.M. and BROOKS, R.M., 1989. *Gulf of Mexico Hindcast Wave Information.* WIS Report 18, U.S. Army Engineer Waterways Experiment Station.

HUBERTZ, J.M. and BRANDON, W.A., 1992. *A Comparison of Measured and Hindcast Wave Conditions at Lake Worth and Hallandale, Florida, During 1990.* Final Report, Coast of Florida Study, Region III. Prepared for U.S. Army Engineer District, Jacksonville. U.S. Army Engineer Waterways Experiment Station.

HUBERTZ, J.M.; BROOKS, R.M.; BRANDON, W.A., and TRACY, B.A., 1993. *Hindcast Wave Information for the Atlantic Coast, 1956-1975.* WIS Report 30, U.S. Army Engineer Waterways Experiment Station.

HUBERTZ, J.M.; DRIVER, D.B., and REINHARD, R.D., 1991. *Hindcast Wave Information for the Great Lakes: Lake Michigan.* WIS Report 24, U.S. Army Engineer Waterways Experiment Station.

LEENKNECHT, D.A. and SZUWALSKI, A., 1992. *Automated Coastal Engineering System: User's Guide, Version 1.07,* U.S. Army Engineer Waterways Experiment Station.

NDBC DATA AVAILABILITY SUMMARY, 1989. Report 1801-24-02, Rev. C, National Data Buoy Center, National Oceanic and Atmospheric Administration.

REINHARD, R.D.; DRIVER, D.B., and HUBERTZ, J.M., 1991. *Hindcast Wave Information for the Great Lakes: Lake Ontario.* WIS Report 25, U.S. Army Engineer Waterways Experiment Station.

REINHARD, R.D.; DRIVER, D.B., and HUBERTZ, J.M., 1991. *Hindcast Wave Information for the Great Lakes: Lake Huron.* WIS Report 26, U.S. Army Engineer Waterways Experiment Station.

SHERLOCK, A.R. and SZUWALSKI, A., 1987. *A User's Guide to the Littoral Environment Observation Retrieval System,* Instruction Report CERC-87-3, U.S. Army Engineer Waterways Experiment Station.

UNIVERSITY OF FLORIDA COASTAL DATA NETWORK (CDN), *Wave Data Report.* 1981 1991, University of Florida: Coastal and Oceanographic Engineering Department.