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CE-QUAL-W2, Version 2.0

by Thomas M. Cole

CE-QUAL-W2 is a two-dimensional, longitudinal/vertical, hydrodynamic, and water quality model developed for rivers, lakes, reservoirs, and estuaries. Version 1.0 was based on the LARM and GLLVHT models developed by J. E. Edinger and E. M. Buchak (Edinger and Buchak 1978, Buchak and Edinger 1984). It was first released in 1986 after inclusion of water quality algorithms (Environmental and Hydraulics Laboratories 1986).

Version 2.0 incorporates many improvements and new capabilities. The newest release has the following capabilities (italics represent a new capability not present in the previous version):

- Water surface elevations, longitudinal and vertical velocities, temperature, and up to 21 water quality constituents can be simulated.
- Multiple branches.
- Head and/or flow boundary conditions.
- Multiple inflows/outflows (tributaries, point/nonpoint sources, releases, withdrawals).
- Layer/segment addition and subtraction (wetting and drying).
- Restart capabilities.
- *Variable segment lengths and layer thicknesses.*
- *Variable time-step calculated internally by the model.*
- *Selective withdrawal.*
- *Higher-order accurate transport scheme.*
- *Internal calculations of equilibrium temperatures and coefficients of surface heat exchange or a term-by-term accounting of surface heat exchange.*
- *Heat exchange between the water/sediment interface.*
- *Linear interpolation of inputs.*
- *Volume and mass balances to machine accuracy.*
- *Improved ice cover algorithm.*

Additional improvements have also been incorporated into the model to make it computationally more efficient and easier to use. Year-long hydrodynamic and water quality simulations with complete algal/nutrient/dissolved oxygen interactions now typically require from 1 to 3 hours of CPU time on a 66-megahertz 486 PC.

Most of the changes resulting in Version 2.0 involved improving the mathematical description of the prototype. Variable segment lengths were incorporated to more accurately represent the bathymetry of the water body. Selective withdrawal was added to reproduce observed release temperatures and improve in-pool predictions. The higher-order transport scheme was incorporated to reduce numerical diffusion, which previously hampered an accurate description of longitudinal/vertical gradients. Reduction in numerical diffusion required the inclusion of sediment/water heat exchange. Interpolation was added to better represent inputs—particularly head boundary conditions for estuarine applications. Volume and mass balance algorithms were implemented to ensure that mass conservation, the fundamental assumption in water quality modeling, was met. Volume and mass balances are now maintained to machine accuracy. The variable time-step was implemented to decrease run times and to ensure that hydrodynamic numerical stability conditions were not violated.

Temperature simulations for three reservoirs are presented in this article to illustrate the model's improved capabilities.

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DeGray Lake

DeGray Lake is a Corps of Engineers reservoir located on the Caddo River in south-central Arkansas and was the site of the initial application of CE-QUAL-W2 (Martin 1987, 1988). The reservoir is a warm monomictic, deep-storage reservoir used for power generation, flood control, and recreation. Table 1 summarizes the reservoir's physical characteristics.

Table 1
DeGray Lake Selected Physical Characteristics

Volume	8.08×10^8 m^3
Surface area	54.3 km^2
Mean depth	14.9 m
Maximum depth	60 m
Residence time (1980)	1.1 years

The original application generated reasonable temperature predictions except during fall when the model overestimated the thermocline depth. However, a wind-sheltering coefficient of 0.3 was used throughout the summer stratification period to reproduce thermocline depth and shape. Observed winds are multiplied by the wind-sheltering coefficient to generate "effective wind speeds," which are used by the model to calculate wind shear and its effect on vertical mixing. Overmixing of the epilimnion during the fall months and the need to use an unrealistically small wind-sheltering coefficient were shown to result from the upwind-differencing transport scheme used in Version 1.0 (Chapman and Cole 1992). The new higher-order differencing scheme allows the model to compute accurate thermocline depths and temperature profiles during stratification using a more realistic wind-sheltering coefficient of 0.85 (Figure 1).

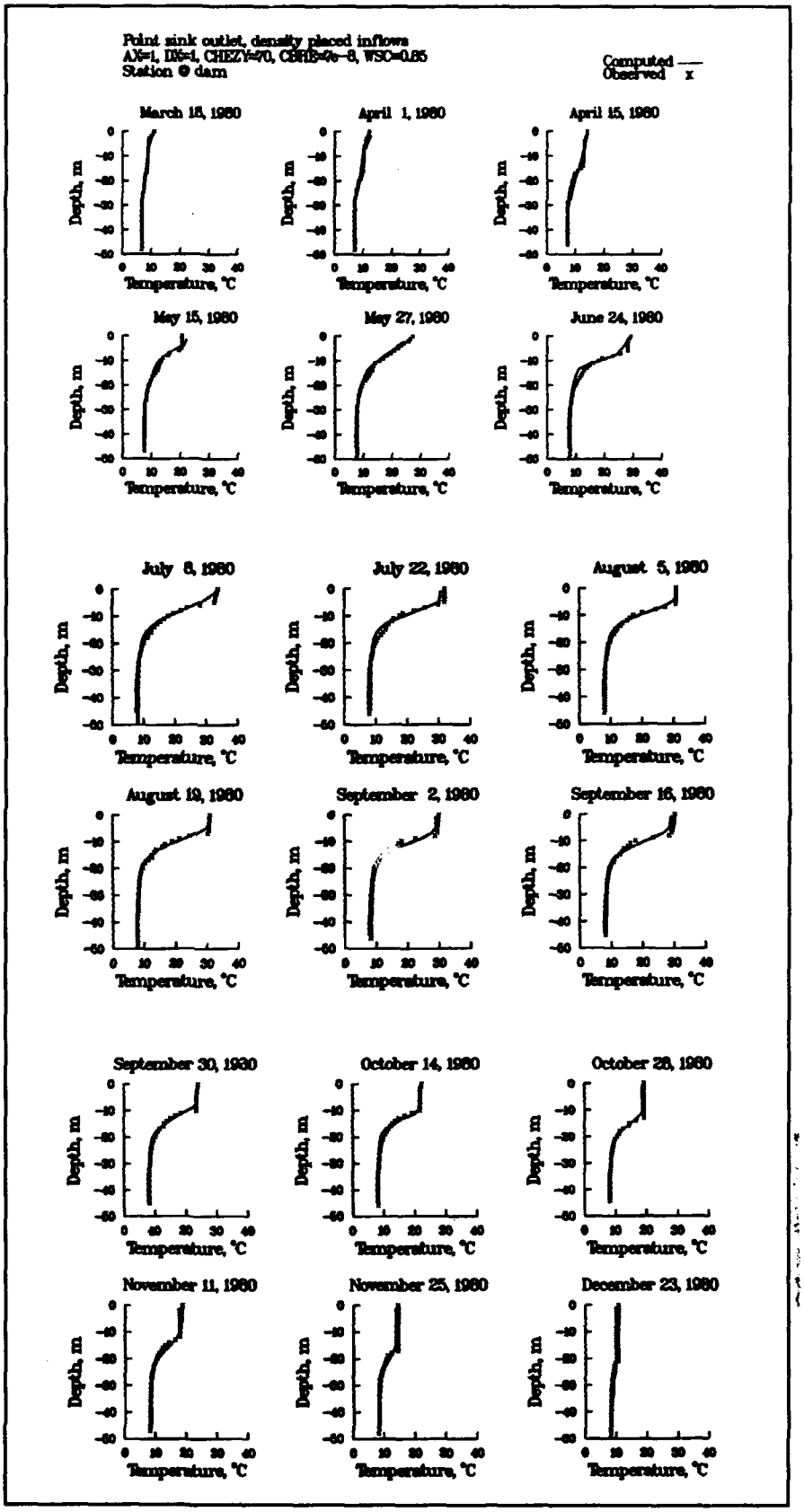


Figure 1. Computed versus observed temperatures for station at dam, DeGray Lake, March 18 - December 23, 1990

Water Quality Bulletin Board (WQBB)

The WQBB is on line! The WQBB is a production of the U.S. Army Engineer Waterways Experiment Station (WES) and the Corps of Engineers' Committee on Water Quality (CWQ). The WQBB is managed at WES through the Water Operations Technical Support (WOTS) Program. The WQBB provides users with access, via modem, to an abundance of water quality information and to other Corps water quality personnel.

Requirements for accessing the WQBB are a computer, communications software, and a Hayes-compatible modem. The WQBB telephone number is (601) 634-4216. To communicate with the WQBB, your computer's communication software must be set to the following:

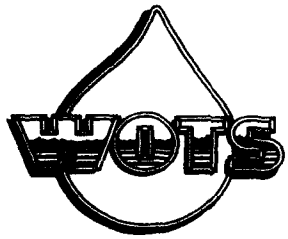
Baud rate	300 to 14,400 (default 2,400)
Data bits	8
Parity	none
Stop bits	1
Video mode	ANSI

To logon, follow the commands on the screen. The first time you logon, you will be asked to complete a questionnaire and choose a password. Ontime usage is limited to 60 minutes per day.

The WQBB provides an opportunity for users to discuss ongoing problems and solutions, upload and download files, and access a calendar of events such as meetings, seminars, and workshops. In addition, the WQBB provides the names and telephone numbers of WES water quality personnel, CWQ members, Field Review Group members for the Corps' Water Quality Research Program (WQRP), and points of contact for water quality at Corps divisions and districts.

Future WQBB additions will include access to the WES Technical Library, electronic requests for WOTS assistance, abstracts of WQRP reports, laws and regulations related to water quality, water quality models, and general information on Corps projects.

If you have any problems, questions, comments, or suggestions concerning the WQBB, please contact Carolyn Schneider, (601) 634-3657, or Bob Gunkel, (601) 634-3722.



This issue highlights the improvements and added capabilities available with the recently released Version 2.0 of CE-QUAL-W2. Temperature simulations for three Corps reservoirs are presented to illustrate application of the model.

WATER QUALITY RESEARCH PROGRAM

This bulletin is published in accordance with AR 25-30. It has been prepared and distributed as one of the information dissemination functions of the Waterways Experiment Station. It is principally intended to be a forum whereby information pertaining to and resulting from the Water Quality Research Program (WQRP) can be rapidly and widely disseminated to Corps District and Division offices as well as other Federal agencies, state agencies, universities, research institutes, corporations, and individuals. Contributions of any type are solicited from all sources and will be considered for publication as long as they are relevant to the objectives of WQRP, i.e., to provide new or improved technology to solve selected environmental quality problems associated with Civil Works activities of the Corps of Engineers in a manner compatible with authorized project purposes. This bulletin will be issued on an irregular basis as dictated by the quantity and importance of information to be disseminated. Communications are welcomed and should be addressed to the Environmental Laboratory, ATTN: J.L. Decell, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call AC 601/634-3494.

ROBERT W. WHALIN, PhD, PE
Director

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
3909 HALLS FERRY ROAD
VICKSBURG, MISSISSIPPI 39180-6199

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