COMPUTER PROGRAMS FOR MODELING FLOW AND WATER QUALITY OF SURFACE WATER SYSTEMS

By

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Introduction

The surface-water research activities of the Water Resources Division frequently result in the preparation of digital computer programs (see Jennings and Yotsukura, 1979). This report describes selected computer programs for modeling flow and/or water quality in surface water systems. The purpose of the brochure is to inform prospective program users concerning program description and use; data requirements; computer costs; availability of documentation and reference material; and to indicate a person to contact for more information. Except in instances where a program is considered under development, prospective USGS users are requested to contact their respective regional surface-water or quality-water specialist concerning program use. Users outside the Geological Survey may contact Chief, Surface Water Branch, U.S. Geological Survey, WRD, 415 National Center, Reston, Virginia 22092. Prospective users of the models described herein are encouraged to study the alternative choices among available models depending on application requirements. To aid in this, Table 2 shows a comparison of watershed model processes and characteristics.

The surface-water models described in this report are grouped in the following categories: (I) Flow models--including watershed models, channel-hydraulics models, river basin models, and reservoir models, and (II) Water-quality models. Table 1 lists the programs by their acronyms or program numbers in the appropriate categories. The page number where the program is described is also included. Most models are available on USGS-owned or contract computer systems, and control card information is available from the respective program developers. A few models are available only as FORTRAN source decks. In addition to models developed "in-house," this report also includes a description of surface-water models developed by other agencies, universities, and consulting firms.

References

Jennings, M. E., and Yotsukura, Nobuhiro, 1979, Status of surface-water modeling in the U.S. Geological Survey: U.S. Geological Survey Circular 809, 17 p.

Table 1.--Programs listed by category with page number and use indicated

Identifier	Use	Page no.
I. FLOW MODELS		
A. Watershed models		
A634X	urban, rural	8
G824	urban, rural	9
DR3M	urban	10
PRMS	rural	11
E784C	urban, rural	13
ANSWERS	rural	14
TENN II	urban, rural	16
HYSIM	rural	18
HSPF	urban, rural	36
B. Channel-hydraulics models		
K634	dam break	20
J349	ground-water interaction	21
J879	unsteady flow - single channel	22
J416	unsteady flow - single channel	23
K757	unsteady flow - network	25
FESWMS	two dimensional	27
C374	slope area	30
A526	culverts	31
E431	steady flow - backwater	32
J635	steady flow - backwater	33
HSPF	kinematic routing - network	36
J351	convolution routing	34
C. River basin models		
J351	streams and reservoirs	34
HSPF	streams	36
D. Reservoir models		
RSFM	reservoir probability	38
A697	reservoir routing	39
II. WATER-QUALITY MODELS		
HSPF	streams and lakes	36
L192	reservoir/lake	42
J880	streams	43
LTM	streams	44
G199	streams	45
G300	streams	46
G301	streams	47
G475	streams	48
DR3M-QUAL	watershed	49
G731	streams and estuaries	51
GENQUAL	streams, lakes, and estuaries	52
J330	streams and estuaries	54
WATEQF	streams	55
BALANCE	streams	56
PHREEQE	streams	57
DUSHRY	estuary	58
QUAL II	streams	59
WQRRS	streams and reservoirs	61

Table 2.--Comparison of Watershed Models. (All watershed models listed below have storm-event simulation capability at a user-specified time interval. The models are also supported by various USGS offices and have available computer programs and documentation.)

MODEL	PRMS	DR3M	G824	A634X	HSPF	ANSWERS	TENN II	HYSIM
CATCHMENT HYDROLOGY								
Distributed hydraulic routing	x	x	ix		x	x		
Multiple rain-gage inputs	x	x	x		x	x		
Snow melt	x				x			
Impervious area runoff	ax	a,jx	ax	x	ax			
Pervious area runoff (Base flow	x				x	x		x
Pervious area runoff (Subsurface flow	x				x			
Pervious area runoff (Surface flow	x	x	x	x	x	x	x	x
Evapotranspiration	x	x	x	x	x			x
Inter-storm soil-moisture accounting	x	x	x	x	x			x
Distributed infiltration	x	bx			x	x		
Physical-based infiltration equation	x	x	x	x	x	x		
Diversions		fx			x			
Detention storage/reservoirs	k	cx			x			
Interception	x				x	x	x	x
Depression storage					x	x		
STORM WATER QUALITY & SEDIMENT								
Sediment erosion and transport	x	x			x	x	x	x
Quality analyses	nx	dx			x		x	
Quality accounting between storms		x			x			
Precipitation quality		x						
Pervious area quality	x	x			x		x	
Impervious area quality		x			x		x	
Transport through channels	x	mx			x			
Detention-storage quality		ex			ex			
CATCHMENT HYDRAULICS								
Pipe flow		x			x			
Overland and channel routing	x	x			x	x		
Pipe surcharging		x			fx			
Pressurized flow								
Backwater conditions								
MISCELLANEOUS								
Continuous simulation	x	gx	gx	gx	x			x
Optimization of parameters	x	x	x	x				
Linked to data-management systems	x	hx	x	x	x			
Flood-frequency package	lx		x	x				
Sensitivity analysis	x							
Primarily designed for:								
Urban watershed analyses		x	x					
Rural watershed analyses	x			x	x	x	x	x

NOTES:
a - affects runoff volume and timing
b - allows for two soil types
c - modified Puls or linear storage
d - options for lumped or distributed quality routing
e - well-mixed only
f - by program manipulation
g - no base flow; continuous multi-event
h - SAS system
i - multiple unit hydrographs
j - considers hydraulic effective and noneffective impervious areas
k - being developed
l - via link of SAS to Geological Survey programs
m - routed as conservatives
n - sediment only

I. FLOW MODELS

A634X–RRMODEL–Natural basin model.

Status: Operational on USGS Amdahl computer system.

Program Use: Calibrates a natural basin by computing storm peaks and volumes and determines optimum magnitudes of 1 to 10 model parameters controlling rainfall-runoff. The model parameters enable computation of soil-moisture accounting, infiltration, and streamflow routing. Model program requires use of several interface programs for execution.

Data Requirements: Card input, plus short-interval precipitation and discharge data, daily precipitation and evaporation totals stored in U.S. Geological Survey WATSTORE computer files.

Computer Costs: $25-$50 per calibration run.

Documentation Available: Yes

References: Carrigan, P. H., Jr., Dempster, G. R., Jr., Bower, D. E., 1977, User's guide for U.S. Geological Survey rainfall-runoff models - revision of Open-File Report 74-33: U.S. Geological Survey Open-File Report 77-884.

Dawdy, D. R., Lichty, R. W., Bergmann, J. M., 1972, A rainfall-runoff simulation model for estimation of flood peaks for small drainage basins: U.S. Geological Survey Professional Paper 506-B, 28 p.

Person to Contact for More Information: Regional Surface-Water Specialists

G824-URBHFM–Urban basin model.

Status: Operational on USGS Amdahl computer system.

Program Use: Calibrates an urban basin by computing storm peaks and volumes and determines optimum magnitudes of 1 to 9 model parameters controlling rainfall-runoff. This model is an extension of the natural basin model (A634X).

Data Requirements: Same as for A634X, plus user supplied planametric units defining the basin time-area histogram for pervious and impervious areas.

Computer Costs: $50 per calibration run.

Documentation Available: Yes

References: Carrigan, P. H., Jr., Dempster, G. R., Jr., Bower, D. E., 1977, User's guide for U.S. Geological Survey rainfall-runoff models - revision of Open-File Report 74-33: U.S. Geological Survey Open-File Report 77-884.

Dawdy, D. R., Lichty, R. W., Bergmann, J. M., 1972, A rainfall-runoff simulation model for estimation of flood peaks for small drainage basins: U.S. Geological Survey Professional Paper 506-B, 28 p.

Person to Contact for More Information: Regional Surface-Water Specialists

DR3M—Distributed routing rainfall—runoff model—version II

Status: Programming and documentation complete; available on USGS Amdahl and Johns Hopkins Univ. (APL) computers.

Program Use: Computes storm runoff from an urban basin. Model requires subdivided catchment data, uses the soil-moisture accounting and infiltration components developed by Dawdy and a Rosenbrock Optimization routine.

Data Requirements: Short-interval precipitation and discharge data, daily precipitation and evaporation totals, subcatchment areas, drainage system, pervious and impervious areas, roughness and hydraulics data.

A data base management system (DBMS) has been developed to aid in organizing and manipulating the data. An interface program between the DBMS and model is also available.

Computer Costs: Generally less than $200 per application.

Documentation Available: Yes

References: Alley, W. M., and Smith, P. E., 1982, Distributed routing rainfall-runoff model--version II: U.S. Geological Survey Open-File Report, in press.

Smith, P. E., and Alley, W. M., 1981, Rainfall-runoff-quality model for urban watersheds: Proceedings, International Symposium on Rainfall-Runoff Modeling, Mississippi State University, p. 24.

Doyle, W. H., and Lorens, J. A., 1982, Data management system for USGS/USEPA national urban hydrology studies program: U.S. Geological Survey Open-File Report, in press.

Person to Contact for More Information:
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PRMS—Precipitation-runoff modeling system

Status: Programming complete--documentation being prepared; available on USGS Amdahl and Johns Hopkins Univ. (APL) computers.

Program Use: A complete watershed system model which computes rainfall- and snowmelt-runoff, sediment discharge, and all water balance components for a watershed and user-defined subunits of a watershed. Rainfall- and snowmelt-runoff are computed as mean daily flows. Rainfall event hydrographs and associated sediment discharge can be simulated for individual storm periods where short time-interval data are available. Optimization and sensitivity analysis capabilities are included.

Data Requirements: For daily streamflow computations a minimum of daily precipitation and daily maximum and minimum air temperature are required. For snowmelt computations daily short-wave solar radiation data are recommended. For areas without snowmelt, daily pan evaporation data can be substituted for temperature data. For storm hydrograph and sediment computations short time-interval precipitation, streamflow, and sediment data are needed. Physical descriptive data on the topography, soils, and vegetation are input for each watershed subunit. The spatial and temporal variation of precipitation, temperature, and solar radiation are also needed.

Computer Costs: Depends on the number of subunits into which a basin is partitioned, the number of storm periods selected for stormflow and sediment computation, and the machine used. Generally less than $1 per year for daily flow computations and for stormflow computations, $2 per storm period.

Documentation Available: Documentation being prepared

References: Leavesley, G. H., Lichty, R. W., Troutman, B. M., and Saindon, L. G., 1981, Precipitation-runoff modeling system: Users' manual: U.S. Geological Survey Water-Resources Investigations, in review.

Person to Contact for More Information:
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Box 25046, M.S. 412
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E784C-AP-SYN

Status: Operational on USGS Amdahl computer system.

Program Use: Program synthesizes a long-term record of annual floods for either natural (A634X) or urban (G824) basins using optimized parameters from the natural or urban basin calibrations.

Data Requirements: Card input, plus short-interval precipitation and daily precipitation and evaporation totals stored in U.S. Geological Survey WATSTORE computer files. For the urban basin, the user must supply the pervious and impervious time-area histogram data.

Computer Costs: $20 per synthesis.

Documentation Available: Yes

References: Carrigan, P. H., Jr., Dempster, G. R., Jr., Bower, D. E., 1977, User's guide for U.S. Geological Survey rainfall-runoff models - revision of Open-File Report 74-33: U.S. Geological Survey Open-File Report 77-884.

Dawdy, D. R., Lichty, R. W., Bergmann, J. M., 1972, A rainfall-runoff simulation model for estimation of flood peaks for small drainage basins: U.S. Geological Survey Professional Paper 506-B, 28 p.

Person to Contact for More Information:
Regional Surface-Water Specialists

ANSWERS—Areal Nonpoint Source Watershed Environment Response Simulation

Status: Program and documentation complete; operational on Johns Hopkins Univ. (APL) computer.

Program Use: Simulates runoff and sediment yield from small rural watersheds for discrete storm events. Catchment response is described in a square-grid matrix superimposed on the watershed. Hydrologic considerations that have been incorporated include interception, infiltration, surface detention, and subsurface drainage. Sediment yield is simulated using modifications of the Universal Soil Loss Equation (USLE) to compute soil detachment and empirical relationships to compute transport.

Data Requirements: Short interval precipitation and antecedent moisture conditions are needed for each storm to be simulated. Soils information includes infiltration parameters and potential soil erodibility. Land use and surface information includes surface roughness and interception and depression storage characteristics. Channel descriptors required are width and roughness. Individual element descriptors are location (in the matrix), topography, and USLE parameters.

Computer Costs: Generally less than $3.00 depending on size of catchment, length of storm, and time steps used.

Documentation Available: Yes

References:
Beasley, D. B., and Huggins, L. F., 1980, ANSWERS (Areal Nonpoint Source Watershed Environment Response Simulation) User's Manual: Agricultural Engineering Department, Purdue University, West Lafayette, Indiana, 55 p.

Curwick, P. B., Doyle, W. H., Jr., and Flynn, K. M., 1982, Evaluation of watershed models that have potential use in surface-mining hydrologic impact assessments: U.S. Geological Survey Water-Resources Investigations, in press.

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TENN II—Watershed model to simulate stormwater runoff and pollutant yields

Status: Operational on Johns Hopkins Univ. (APL) computer.

Program Use: Program can be used to evaluate the effects of land use change on storm water runoff and its associated quality. The model can simulate storm hydrographs and pollutant yields from small watersheds using real time or design rainfall events. Runoff volume and the associated rainfall excess time-distribution are simulated from input rainfall using the Soil Conservation Service Curve Number model. The outflow hydrograph is computed by convoluting the rainfall excess distribution with a TVA double triangle unit hydrograph. TENN II makes provision for simulating the unit hydrograph from input watershed characteristics. TENN II also simulates sediment (and other constituents) loads for the storm. This simulation is a function of the input land-use and storm characteristics.

Data Requirements: A watershed is considered to be a lumped system, and the required input data are: rainfall, percent of watershed that is forested, percent that is impervious, percent that is surface mined or denuded, curve number, and drainage area.

Computer Costs: Generally less than $0.50 per storm.

Documentation Available: Yes

References:
Overton, D. E., 1980, Computer program TENN II user's manual: D. E. Overton Associates, Environmental Planning Engineers, Inc., Knoxville, Tenn., 21 p.

Curwick, P. B., Doyle, W. H., Jr., and Flynn, K. M., 1982, Evaluation of watershed models that have potential use in surface-mining hydrologic impact assessments: U.S. Geological Survey Water-Resources Investigations, in press.

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HYSIM—Hydrologic Simulation Model

Status: Operational on Johns Hopkins Univ. (APL) computer.

Program Use: Designed to be used for assessing the impacts of land-use change, including surface mining, on the hydrologic balance of a watershed. The model is capable of simulating daily streamflows and stormflows for small watersheds. Suspended sediment may also be simulated in conjunction with daily streamflow or storm hydrographs. Watershed response is computed using a lumped approach.

In its present configuration, using the stochastic rainfall generator, this model can be used at a time-sharing terminal to generate long term sequences of annual runoff yields, flood peak discharges, and sediment yields.

Data Requirements: Regionalized model relationships were incorporated to minimize input data requirements. Rainfall data may be stochastically generated or input directly by the user. For daily streamflow simulations, monthly potential evapotranspiration data are needed. Watershed characteristics, typically obtained from topographic and soils maps are necessary input. All input data may be entered interactively on a time-sharing terminal, wherein the computer prompts the users for the necessary information.

Computer Costs: Generally less than $1.50 per year for daily flow simulations and less than $2.00 when storm simulations are included.

Documentation Available: Yes

References: Betson, R. P., Bales, J., Pratt, H. E., 1980, User's guide to TVA-HYSIM, a hydrologic program for quantifying land-use change effects: Tennessee Valley Authority, EPA-600/7-80-048, 107 p.

Curwick, P. B., Doyle, W. H., Jr., and Flynn, K. M., 1982, Evaluation of watershed models that have potential use in surface-mining hydrologic impact assessments: U.S. Geological Survey Water-Resources Investigations, in press.

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K634—Dam-break flood simulation model

Status: Program and documentation complete; operational on Johns Hopkins Univ. (APL) computer.

Program Use: Simulates dam-break floods for forecast purposes. The program is a version of the National Weather Service DAMBRK model that was modified by Land (1980b) for general purpose applications. Streamflow is routed using the St. Venant equations for unsteady flow solved by a nonlinear implicit finite difference method. For reservoir routing a hydrologic method may be used or the hydraulic method used for streamflow.

Data Requirements: Reservoir and channel geometry, inflow hydrograph to reservoir, channel roughness coefficients, reservoir structure parameters, size and shape of breach, duration of breach development, channel dead storage areas.

Computer Costs: Less than $50.

Documentation Available: Yes

References: Fread, D. L., 1981, Some limitations of dam-break flood routing models: Proceedings, 1981 ASCE Fall Convention, Oct. 26-30, 1981, St. Louis, Missouri, 15 p.

Land, L. F., 1980a, Evaluation of selected dam-break flood-wave models by using field data: U.S. Geological Survey Water-Resources Investigations 80-44.

Land, L. F., 1980b, User's guide for a general purpose dam-break flood simulation model (K-634): U.S. Geological Survey Water-Resources Investigations 80-116.

Person to Contact for More Information:
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NSTL Station, MS 39529

J349—Streamflow routing with losses to bank storage or wells

Status: Program and documentation complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Routes discharges through an alluvial channel using diffusion analogy and convolution techniques. An accounting is made for the effects of bank storage and pumping wells.

Data Requirements: Inflow discharge hydrograph, rating tables at beginning and end of reach, aquifer properties, routing parameters.

Computer Costs: Generally less than $200 per application.

Documentation Available: Yes

References: Land, L. F., 1977, Streamflow routing with losses to bank storage or wells: U.S. Geological Survey Computer Contribution, 117 p.

Person to Contact for More Information:
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J879—Unsteady streamflow simulation using a linear implicit finite difference model

Status: *Program and documentation complete; operational on Johns Hopkins Univ. (APL) computer.*

Program Use: *Computes the discharge and depth hydrographs at any point in a reach for one-dimensional, subcritical, gradually varied unsteady flow. Computes data commonly needed by mass transport models.*

Data Requirements: *Depth or discharge hydrographs at upstream and downstream boundaries of channel reach, channel geometry, and channel roughness.*

Computer Costs: *Highly variable, but generally less than $100 per run.*

Documentation Available: *Yes*

References: *Land, L. F., 1978, Unsteady streamflow simulation using a linear implicit finite difference model: U.S. Geological Survey Water-Resources Investigations 78-59, 59 p.*

Person to Contact for More Information:
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J416—Unsteady flow routing using method of characteristics

Status: *Program and documentation complete; available from authors as FORTRAN IV source program.*

Program Use: *Simulation of unsteady flows in rivers and estuaries by the multiple-reach method of characteristics. Outputs: There are 8 output options, including complete output table (stage, velocity, discharge at many points along the reach at any time); summary of downstream and upstream flow volumes; daily mean discharge; measured and computed flow plotting; concise discharge table; multi-flow plotting; recorded and computed stage plotting.*

Data Requirements: *Time-dependent data at two ends of the reach. Any of the following pairs may be used: stage-stage; stage-velocity (discharge); velocity (discharge) - stage; velocity (discharge) - velocity (discharge) with accurate initial value data (velocities or discharges and stages along the reach); channel geometry.*

Computer Costs: *Varies depending on the length of simulation.*

Documentation Available: *Yes*

References: *Baltzer, R. A., and Lai, C., 1968, Computer simulation of unsteady flows in waterways: Journal of Hydraulics Division, ASCE, v. 94, no. HY4, p. 1083-1117.*

Lai, C., 1967, Computation of transient flows in rivers and estuaries by the multiple-reach method of characteristics: Geological Survey Research, U.S. Geological Survey Professional Paper 575-D, p. D273-D280.

Lai, C., and Onions, C. A., 1976, Computation of unsteady flows in river and estuaries by the method of characteristics: U.S. Geological Survey Computer Contribution 76-034, PB253785, 195 p.

Lai, C., Schaffranek, R. W., and Baltzer, R. A., 1978, An operational system for implementing simulation models, a case study: Seminar on Comp. Hyd., Proceedings, ASCE 26th Annual Hydraulics Specialty Conference, University of Maryland, p. 415-454.

Oltmann, R. N., 1980, Extension of transient flow model of the Sacramento River, at Sacramento, California: U.S. Geological Survey Water-Resources Investigations 80-30, 25 p.

Person to Contact for More Information:

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National Center, M.S. 430
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K757–BRANCH (Branch-Network Flow Model)

Status: The model, supported by direct-access boundary-condition data files, is operational on the Amdahl V-7 computer system. A variety of graphical output options are also provided and available for use. The model may be called using program and procedure libraries on the Amdahl System. Documentation complete.

Program Use: BRANCH is a complete numerical model for simulating the one-dimensional, unsteady flow in singular riverine or estuarine reaches and in networks of reaches composed of inter-connected channels. The model uses a four-point, implicit, finite-difference approximation of the unsteady flow equations.

Data Requirements: Channel geometry describing the various reaches are used to particularize the model for a specific prototype situation. Initial flow conditions at a particular moment in time may be prescribed as observed in the field or may be assumed. Time series of boundary conditions, i.e., water levels, discharges, or relational conditions at channel cross sections that are external to the model may be input directly or called from previously prepared direct-access data files.

Computer Costs: Computer costs vary with the size and complexity of the particular model being executed. Typical examples of model application and utilization are given in the referenced report below. Cost for these example applications are given in Chapter 4 of this report.

Documentation Available: Yes

References: Schaffranek, R. W., Baltzer, R. A., and Goldberg, D. E., 1981, A model for simulation of flow in singular and interconnected channels: U.S. Geological Survey Techniques of Water-Resources Investigations, Chapter 3, Book 7.

Person to Contact for More Information:
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FESWMS—Finite-element surface-water modeling system (two-dimensional hydrodynamics in the horizontal plane)

Status: *The system has been thoroughly tested under field conditions for steady-state problems. Documentation of the flow model around which the system is built has been prepared by Resource Management Associates and is available. Documentation of the entire system is in preparation by the USGS. Extensive consultation with Physical Models project staff is suggested before attempting use. Program available on Johns Hopkins Univ. (APL) computer.*

Program Use: *Computes steady or unsteady water-surface elevations and vertically averaged velocity components at the nodes of a finite-element network. Most applications have involved the steady-state analysis of complex highway crossings and other modifications of river flood plains. The capability to model different length scales in a single network is one of the advantages of the finite-element method.*

Data Requirements: *The following data are required for flood-plain modeling. Similar data are required for estuary modeling. Flood discharge and flood-plain boundaries. Spatial description of flood-plain bottom geometry, including channel cross sections, if necessary. Spatial description of flood-plain roughness. Upstream discharge distribution, including tributary inflows, if any. Downstream water-surface elevations. For a time-dependent problem, these boundary data must be available as functions of time. Calibration data, both water-surface elevations and local velocities. These are especially important near regions of large gradients in the dependent variables, such as near bridge openings.*

Computer Costs: Estimated cost for developing and running a single network with approximately 1000 elements is $1000-$2000. Computer costs for a complex project involving the study of a number of alternatives range from $5000 to $25,000.

Documentation Available: Yes

References: Gee, D. M., and MacArthur, R. C., 1978, Development of generalized free surface flow models using finite element techniques, in Brebbia, C. A., and others, eds., Finite elements in water resources: International Conference on Finite Elements in Water Resources, 2nd, London, 1978, Proceedings: London, Pentech Press, p. 2.61-2.79.

King, I. P., and Norton, W. R., 1978, Recent applications of RMA's finite element models for two-dimensional hydrodynamics and water quality in Brebbia, C. A., and others, eds., Finite elements in water resources: International Conference on Finite Elements in Water Resources, 2nd, London, 1978, Proceedings: London, Pentech Press, p. 2.81-2.99.

Lee, J. K., 1980, Two-dimensional finite element analysis of the hydraulic effect of highway bridge fills in a complex flood plain, in Wang, S. Y., and others, eds., Finite elements in water resources: International Conference on Finite Elements in Water Resources, 3rd, University, Miss., 1980, Proceedings: University, Miss., The University of Mississippi, School of Engineering, p. 6.3-6.23.

Lee, J. K., 1981, A finite-element model study of the impact of the proposed I-326 crossing on flood stages of the Congaree River near Columbia, South Carolina: U.S. Geological Survey Open-File Report 81-1194, 56 p.

Norton, W. R., and King, I. P., 1973, A finite element model for Lower Granite Reservoir, computer application supplement and user's guide: Walnut Creek, Calif., Water Resources Engineers, Inc., 90 p.

Norton, W. R., King, I. P., and Orlob, G. T., 1973, A finite element model for Lower Granite Reservoir: Walnut Creek, Calif., Water Resources Engineers, Inc., 138 p.

Tseng, M. T., 1975, Finite element model for bridge backwater computation, v. III of Evaluation of flood risk factors in the design of highway stream crossings: Washington, D.C., Federal Highway Administration, Report No. FHWD-RD-75-53, 176 p.

U.S. Army Corps of Engineers, 1976, Flood hazard information (technical appendix), Rio Grande de Loiza, Puerto Rico: Jacksonville, Florida, U.S. Army Corps of Engineers, 29 p.

Person to Contact for More Information:
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C374–SWSLOPE–Computation of discharge by the slope-area method.

Status: Operational on USGS Amdahl computer system.

Program Use: The program computes the discharges for each component subreach and for the entire reach for a single flood event.

Data Requirements: The data needed to perform these computations include: cross-section geometry, roughness coefficients, reach lengths, and fall of water-surface elevation in each subreach.

Computer Costs: About $5 per discharge (class D).

Documentation Available: Yes

References: Dalrymple, J., and Benson, M. A., 1967, Measurement of peak discharge by the slope-area method: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A2, 12 p.

Lara, O. G., and Davidian, J., 1970, Preparation of input data for automatic computation of discharge by slope-area method, unpublished report.

Person to Contact for More Information: Regional Surface-Water Specialists

A526–SWCULRAT–Stage-discharge relations at culverts.

Status: Operational on USGS Amdahl computer system.

Program Use: The program computes a full stage-discharge relationship for a range of discharges and tailwater elevations selected by the operator for single-barreled circular pipes, riveted or multiplate pipe-arches, and rectangular box culverts with or without webs.

Data Requirements: The data needed to perform these computations include: approach cross-section geometry, culvert geometry, roughness and entrance coefficients, reach length and culvert length, and assorted discharges and tailwater elevations for which the computed headwater (approach cross-section) elevations are desired.

Computer Costs: Less than $5 per run (class D).

Documentation Available: Yes

References: Bodhaine, G. L., 1968, Measurement of peak discharge at culverts by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A3, 60 p.

Matthai, H., Stull, B., and Davidian, J., Preparation of input data for automatic computation of stage-discharge relations at culverts, unpublished report.

Person to Contact for More Information: Regional Surface-Water Specialists

E431—Step-backwater and floodway analyses.

Status: Operational on USGS Amdahl computer system.

Program Use: The program computes water-surface profiles for gradually varied, subcritical flow for both existing stream conditions and stream conditions as modified by encroachments.

Data Requirements: Required data include cross-section geometry and roughness; bridge geometry and coefficients; roadway geometry and coefficients; flow distances; discharges and starting elevations. Extensive data editing is performed which provides the user with descriptive messages for a very high percentage of possible data coding errors.

Computer Costs: Less than $10 for class D (depends on reach length and complexity).

Documentation Available: Yes

References: Shearman, James O., 1976, Computer applications for step backwater and floodway analysis: U.S. Geological Survey Open-File Report 76-499, 103 p.

Person to Contact for More Information: Regional Surface-Water Specialists

J635—Step backwater and floodway analyses

Status: Operational on USGS Amdahl computer system.

Program Use: The program is an extensively modified version of computer program E431. The program computes water-surface profiles for gradually varied, subcritical or supercritical flow for both existing stream conditions and stream conditions as modified by encroachments.

Data Requirements: Required data include cross-section geometry and roughness; bridge geometry and coefficients; roadway geometry and coefficients; flow distances; discharges and starting elevations. Extensive data editing is performed which provides the user with descriptive messages for a very high percentage of possible data coding errors.

Computer Costs: $2 per run.

Documentation Available: Yes

References: Class notes available.

Person to Contact for More Information: Regional Surface-Water Specialists

J351—Hourly-daily streamflow routing by convolution of unit responses

Status: *Program and documentation complete; program available on Johns Hopkins Univ. (APL) computer.*

Program Use: *Routes hourly or daily streamflow through a reach or a succession of reaches of open channel in a downstream direction. Routing computations may be by (1) diffusion analogy method with either single or multiple linearization of discharges and response function(s) or (2) unit hydrograph analogy (storage-continuity) and a convolution technique. Streamflows from ungaged areas may be estimated by a drainage-area ratio. J351 may be used in conjunction with: (1) reservoir, (2) upstream routing, and (3) stream-aquifer interaction models. J351 may be used to provide input to sediment scour and deposition models and for sediment transport computations. J351 output files may be analyzed using streamflow statistics programs.*

Data Requirements: *Adequate combinations of long-term and short-term daily streamflow records at strategic locations. Also requires routing parameters.*

Computer Costs: *Calibration of a reach may range from less than $50 to more than $200 depending upon characteristics of the data and user's skill. A 30-year simulation run (with no hardcopy output) may range from less than $5 to about $10 per reach. Hardcopy output and statistical analyses costs are greatly dependent upon the I/O costs of the computer installation being utilized and probably range from $15 to over $100 per reach for a 30-year record.*

Documentation Available: *Yes*

References: *Keefer, T. N., 1974, Desktop computer flow routing: American Society of Civil Engineers, Journal of the Hydraulics Division, no. HY7, p. 1047-1058, Proc. Paper 10669.*

Keefer, T. N., and McQuivey, R. S., 1974, Multiple linearization flow routing model: American Society of Civil Engineers, Journal of the Hydraulics Division, v. 100, no. HY7, p. 1031-1046.

Sauer, V. B., 1973, Unit-response method of open-channel flow routing: American Society of Civil Engineers, no. HY1, p. 179-193, Proc. Paper 9499.

Shearman, J. O., Stiltner, G. J., and Doyle, W. H., Jr., 1979, A digital model for streamflow routing by convolution methods: U.S. Geological Survey water-resources investigations (draft).

Shearman, J. O., and Swisshelm, R. V., Jr., 1973, Derivation of homogeneous streamflow records in the upper Kentucky River Basin, south-eastern Kentucky: U.S. Geological Survey Open-File Report, 34 p.

Person to Contact for More Information:

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NSTL Station, MS 39529

Status: Operational on USGS Harris computer in Reston, Va., and APL.

Program Use: Program converts continuous rainfall and other meteorologic records into streamflow hydrographs and pollutographs. Simulates interception soil moisture, surface runoff, interflow, baseflow, snowmelt, evapotranspiration, ground water recharge, DO, BOD, temperature, pesticides, conservatives, fecal coliforms, sediment by particle size, channel routing, reservoir routing, constituent routings, pH, ammonia, nitrite-nitrate, organic nitrogen, orthophosphate, organic phosphorus, phytoplankton, and zooplankton. Program can include one or many pervious or impervious unit areas discharging to one or many river reaches or reservoirs. Frequency-duration analysis can be done for any time-series. Output is either printed tables at any time-step or sequential files on disk. Any time step from 1 minute to 1 day that divides equally into 1 day can be used. Any period from a few minutes to many years may be simulated. HSPF is not effective for a one-time application, but can be very effective in repeated applications such as assessing the effects of land use change, reservoirs, point or nonpoint source treatment alternatives, flow diversions, etc. A separate program is available for graphic output of any constituent at any time step for any length of time.

Data Requirements: Meteorologic records of precipitation and estimates of potential evapotranspiration are required for watershed simulation. For snowmelt, air temperature, dew point temperature, wind and solar radiation are required. For water-quality simulation, air temperature, wind, solar radiation, humidity, cloud cover, tillage practices, point sources, and/or pesticide applications may be required. Physical measurements and related parameters are required to describe the land area, channels, and reservoirs. A separate program is available in an interactive mode to develop the

input data. The user is prompted by the computer, given help, has the data checked, and is guided through the input requirements. Separate programs also are available to reformat data from WATSTORE and the data tapes from the National Climatic Center.

Computer Costs: From a few dollars to hundreds of dollars depending on time period, time step, number of land segments and river reaches, and number of water-quality constituents. A cost equation has not been developed yet. Simulation of snowmelt and components of runoff at a 1-hour time step costs about $3 per year at commercial rate. Simulation of flow in a reach at a 1-hour time step costs about $1 per year at commercial rates.

Documentation Available: Yes

References: Johanson, R. C., Imhoff, J. C., and Davis, H. H., Jr., 1980, Users manual for hydrological simulation program - Fortran (HSPF): Environmental Research Laboratory, EPA-600/9-80-015, Athens, Ga., April, 1980.

Person to Contact for More Information:

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Tom Barnwell
U.S. Environmental Protection Agency
Environmental Research Laboratory
Athens, GA 30605

RSFM—Reservoir-storage frequency model

Status: Program and documentation complete; available as a FORTRAN source deck.

Program Use: Computes probabilities of reservoir storage including the risks of being unable to supply downstream demand. Simulates the behavior of ephemeral and intermittent streams by accounting for high day-to-day variations in streamflow as well as zero-flow periods. Probability routing of daily mean streamflow is used.

Date Requirements: A record of daily mean streamflow along with reservoir-storage capacity and an outflow function are always required. The outflow function may vary daily and may be computed as a function of reservoir storage. Optional data includes reservoir evaporation as a function of surface area. Reservoir-storage frequencies for several assumed reservoir-storage capacities and outflow functions may be computed in a single program run.

Computer Costs: Computer costs vary with the amount of streamflow record available. A typical cost for 25 years of record is $3.00 per reservoir-storage capacity and outflow function. A complete analysis of a streamflow record can be accomplished for less than $100.

Documentation Available: Yes

References: Glover, Kent C., 1982, Model for the analysis of reservoir storage frequency in semi-arid regions: U.S. Geological Survey Water-Resources Investigations, in press.

Person to Contact for More Information:
Kent Glover
U.S. Geological Survey, WRD
Box 1125
Cheyenne, WY 82001

A697—Downstream-upstream reservoir routing

Status: Operational on Johns Hopkins Univ. (APL) computer.

Program Use: This program can be used to route an inflow hydrograph (downstream routing) through an uncontrolled reservoir to obtain an outflow hydrograph; or by specification of a code, the program can be used to route an outflow hydrograph (upstream routing) to obtain the inflow hydrograph.

Data Requirements: Inflow or outflow hydrograph ordinates at specified time interval and elevation-outflow-storage data.

Computer Costs: Less than $10.

Documentation Available: Yes

References: Jennings, Marshall E., 1977, Downstream-upstream reservoir routing: U.S. Geological Survey Computer Contribution, 42 p.

Person to Contact for More Information:
Regional Surface-Water Specialists

II. WATER-QUALITY MODELS

L192—One-dimensional reservoir/lake temperature and dissolved oxygen model

Status: Program complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Best suited to predict the probable DO and temperature conditions in a proposed lake or reservoir, or to compare the effects of altering the outflow withdrawal elevation of an existing or proposed lake or reservoir. Biochemical oxygen demand and sediment oxygen demand also can be simulated.

Data Requirements: Daily input values of average equilibrium air temperature, surface heat exchange coefficients, inflow and outflow values, and the water-quality information associated with the inflowing water.

Computer Costs: Approximately $60 per year of simulation.

Documentation Available: Yes

References: House, L. B., 1982, One-dimensional reservoir/lake temperature and dissolved oxygen model: U.S. Geological Survey Water-Resources Investigations 82-5, 112 p.

Person to Contact for More Information: Regional Quality-Water Specialists

J880—Unsteady solute transport simulation in streamflow using a finite difference model

Status: Program and documentation complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Computes solute concentration pollutographs at any point in a stream having one-dimensional streamflow.

Data Requirements: Solute inflows at upstream boundary, tributaries and source or sinks. Flow data at each time step and cross section. Designed to be used with J879 for the supply of flow data.

Computer Costs: Highly variable, generally less than $100, not including use of J879.

Documentation Available: Yes

References: Land, L. F., 1978, Unsteady solute simulation in streamflow using a finite difference model: U.S. Geological Survey Water-Resources Investigations 78-18.

Person to Contact for More Information: Regional Quality-Water Specialists

LTM—Lagrangian transport model

Status: Fully operational on Johns Hopkins Univ. (APL) computer.

Program Use: Routes up to 10 interacting constituents through a river.

Data Requirements: Flow: areas, top widths, and velocities; if unsteady, these data are needed for each time step. Initial conditions: concentration of each constituent at each grid at time zero. Boundary conditions: concentration of each constituent at upstream and in each tributary at each time step.

Computer Costs: Less than $10 per run.

Documentation Available: Yes

References: Jobson, H. E., 1981, Temperature and solute-transport simulation in streamflow using a Lagrangian reference frame: U.S. Geological Survey Water-Resources Investigations 81-2, 165 p.

Person to Contact for More Information Regional Quality-Water Specialists

G199—Surface jet stream excess temperature analysis

Status: Program and documentation complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Predicts two-dimensional behavior of a heated surface jet discharging into an ambient flowing stream.

Data Requirements: Jet configuration and related hydraulic discharge and temperature data. Data, spaced at 1/2-mile intervals or less, should be collected seasonally.

Computer Costs: Less than $10 per application.

Documentation Available: Yes

References: Bauer, D. P., and Motz, L. H., 1973, Surface jet stream excess temperature analysis: U.S. Geological Survey Computer Contribution, 32 p.

Person to Contact for More Information: Regional Quality-Water Specialists

G300—Two-dimensional excess temperature model for a thermally loaded stream

Status: Program and documentation complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Computes distribution of excess temperature (or soluble contaminants) in a steady-flow two-dimensional stream using a stream-tube concept.

Data Requirements: Channel reach properties, waste-heat discharge, stream discharge distribution, temperature data. Data, spaced at 1/2-mile - 2-mile intervals should be collected seasonally.

Computer Costs: Less than $50 per typical application

Documentation Available: Yes

References: Bauer, D. P., and Yotsukura, N., 1974, Two-dimensional excess temperature model for a thermally loaded stream: U.S. Geological Survey Computer Contribution, 125 p.

Person to Contact for More Information: Regional Quality-Water Specialists

G301—One-dimensional stream excess temperature analysis

Status: Program and documentation complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Predicts one-dimensional stream excess temperatures in a flowing stream.

Data Requirements: Windspeed, stream and heated water discharges, stream temperature data. Data, spaced at 1-10 miles, should be obtained seasonally.

Computer Costs: Less than $10 per typical application.

Documentation Available: Yes

References: Bauer, D. P., and Mackenroth, E., 1974, One-dimensional stream excess temperature analysis: U.S. Geological Survey Computer Contribution, 31 p.

Person to Contact for More Information: Regional Quality-Water Specialists

G475—Steady-state water-quality model

Status: Program and documentation complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Computes concentrations of dissolved oxygen, biochemical oxygen demand (using CBOD and NBOD or CBOD and nitrogen cycle variables), phosphorus, and total and fecal coliforms. Options include handling linear runoff and anaerobic conditions.

Data Requirements: Short-term oxygen, CBOD, NBOD, or nitrogen cycle variables, and coliform concentrations at several points in the stream network; flow and stream geometry data; point source and linear runoff waste data; reaeration and other model parameters. Verification requires 2 to 5 data sets.

Computer Costs: Less than $200 for a typical application.

Documentation Available: Yes

References: Bauer, D. P., Jennings, M. E., and Miller, J. E., 1978, One-dimensional steady-state stream water-quality model: U.S. Geological Survey Water-Resources Investigations 79-45, 219 p.

Jennings, M. E., and Bryant, C. T., 1973, Water-quality modeling for waste load allocation studies in Arkansas--stream dissolved oxygen and conservative minerals: U.S. Geological Survey Open-File Report, 16 p.

McCutcheon, S. C., 1981, The evaluation of selected one-dimensional stream water quality models with field data: U.S. Army Corps of Engineers Technical Report, in press.

Person to Contact for More Information: Regional Quality-Water Specialists

DR3M-QUAL—Multi-event urban runoff quality model

Status: Program complete; documentation nearing completion; available on USGS Amdahl computer system.

Program Use: Simulates the concentration, as a function of time, of pollutants in runoff from urban watersheds. Computations are made considering three sources of pollutants: impervious areas, pervious areas, and precipitation. The program provides detailed simulation of storm events specified by the user and a daily accounting of pollutant accumulation on impervious areas between storm events. Algorithms for simulating detention storage and street sweeping are included. The program is designed to operate with flow hydrographs computed by DR3M.

The program is useful for urban stormwater quality studies. It is well suited for determining the effects of urbanization on stormwater quality, evaluating stormwater management strategies, and estimating urban non-point source pollutant loadings on receiving waters.

Data Requirements: Short-time interval discharge data, daily precipitation and evaporation totals, drainage system data similar to DR3M, information on the frequency and efficiency of street sweeping, geometry data for detention basins, information on precipitation quality, estimates of model water-quality parameters, and within-storm water-quality data for events where automatic calibration is to be used.

A data base management system (DBMS) has been developed to aid in organizing and manipulating the data. An interface program between the DBMS and model is also available.

Computer Costs: Generally less than $200 per application.

Documentation Available: Yes

References: Alley, W. M., and Smith, P. E., 1982, Multi-event urban runoff quality model: U.S. Geological Survey Open-File Report, in review.

Smith, P. E., and Alley, W. M., 1981, Rainfall-runoff-quality model for urban watersheds: Proceedings, International Symposium on Rainfall-Runoff Modeling, Mississippi State University, 24 p.

Doyle, W. H., and Lorens, J. A., 1982, Data management system for USGS/USEPA national urban hydrology studies program: U.S. Geological Survey Open-File Report, in press.

Person to Contact for More Information:
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G731–Determination of biochemical oxygen demand (BOD) parameters

Status: Program and documentation complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Computes rate constant and ultimate BOD from a series of laboratory-determined BOD values. Includes linear and nonlinear fitting options, and nitrogenous BOD parameters can be obtained using a program option requiring use of two data sets. The program has an associated TSO-based data management system.

Data Requirements: Laboratory measurements of dissolved oxygen and other measurements on a series of incubated waste samples. At least five to eight sequential BOD determinations are recommended.

Computer Costs: Less than $1 per data set.

Documentation Available: Yes

References: Jennings, M. E., and Bauer, D. P., 1976, Determination of biochemical oxygen demand parameters: U.S. Geological Survey Computer Contribution, 55 p.

Person to Contact for More Information:
Regional Quality-Water Specialists

GENQUAL—General purpose water-quality model

Status: Programming complete - documentation being prepared; program available on the USGS Amdahl computer.

Program Use: General purpose water-quality model based on an Eulerian transport formulation (box model). Capable of simulating up to 10 user-defined water-quality constituents in an upland stream, lake, or estuary. The model can be configured in 1, 2, or 3 dimensions spatially, provided the flow field and dispersion coefficients are known. The model is fully dynamic and can accommodate up to 40 time-variable inputs of which flows, dispersion coefficients, segment geometry, boundary conditions, and loadings are predefined, and fourteen other variables can be uniquely defined by the user. Likewise, each reaction coefficient can be changed dynamically. Changes in input variables or reaction coefficients may be done by use of special algorithms defined by the user. Each modeled constituent may or may not interact with any of the other modeled constituents.

Data Requirements: Initial constituent concentrations, loads, boundary conditions, flows, dispersion, and geometry data for each stream segment to be modeled. Also, user must specify the nature of the interactions between modeled constituents.

Computer Costs: Less than $5 per simulated month for a ten-segment BOD-DO problem to $50 per simulated month for a 40 segment, 10 constituent ecological model involving phytoplankton-nutrient-DO interactions.

Documentation Available: In preparation.

References:
Smith, R. A., 1976, The effectiveness of advanced waste treatment in improving water quality in the Back River Estuary: Report to the Department of Public Works of Baltimore City.

Thomann, R. V., 1972, Systems analysis and water-quality management: McGraw-Hill, New York, 286 p.

Person to Contact for More Information:
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J330—Determination of primary production and community metabolism using diel oxygen measurements

Status: Program and documentation complete; available on Johns Hopkins Univ. (APL) computer.

Program Use: Calculates daytime net productivity, night respiration, and total community metabolism from diel series of dissolved oxygen, temperature, and salinity measurements for streams, lakes, and estuaries. Results may be used as input to programs G475 and LTM, when BOD is relatively low.

Data Requirements: Diel oxygen, temperature, salinity measurements or profiles at 2-3 hour intervals. Data collection should be repeated seasonally.

Computer Costs: Less than $50 per application.

Documentation Available: Yes

References: Stephens, D. W., and Jennings, M. E., 1976, Determination of primary productivity and community metabolism using diel oxygen measurements: U.S. Geological Survey Computer Contribution.

Person to Contact for More Information: Regional Quality-Water Specialists

WATEQF—Chemical equilibrium of natural waters

Status: The program and its thermodynamic data file (TABLES) is operational on the USGS Amdahl computer system.

Program Use: WATEQF calculates the thermodynamic speciation of inorganic ions in solution for one or more water analyses. Saturation indices of approximately 120 minerals are calculated for testing possible mineral controls on water composition.

Data Requirements: A chemical analysis of the water including pH and temperature. The analysis should include the major species (such as Ca, Mg, Na, K, Cl, SO_4, HCO_3) and may also include SiO_2, Fe, PO_4, Sr, F, H_2S, CO_3, NH_4, Al, Li, NO_3, H_2CO_3, B, Ba, Br, and Mn.

Computer Costs: Computer costs vary with the number of chemical species in the analysis, but generally lie in the range of 0.2 sec/analysis.

Documentation Available: Yes

References: Plummer, L. N., Jones, B. F., and Truesdell, A. F., 1976, WATEQF - A FORTRAN IV version of WATEQ, a computer program for calculating chemical equilibrium of natural waters: U.S. Geological Survey Water-Resources Investigations 76-13, 63 p.

Person to Contact for More Information: Regional Quality-Water Specialists

BALANCE—Geochemical reactions

Status: *In preparation. Available on U.S. Geological Survey Amdahl computer.*

Program Use: *Calculation of amounts of minerals which must dissolve or precipitate to account for observed differences in water composition along a flow path.*

Data Requirements: *Chemical analyses for two waters along a flow path. A knowledge of minerals in contact with the water and minerals likely to form from the water (including gases).*

Computer Costs: *Essentially the base cost for making a run of a given class. Almost no CPU time.*

Documentation Available: *No*

References: *Parkhurst, D. L., Plummer, L. N., and Thorstenson, D. C., BALANCE - a computer program for calculating mass transfer for geochemical reactions in ground water: U.S. Geological Survey Water-Resources Investigations (in preparation).*

Person to Contact for More Information:
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PHREEQE—Chemical reactions in natural waters

Status: *Published. Available on Reston Amdahl and possibly on one of the Denver Survey computers with necessary thermodynamic data.*

Program Use: *Simulation of chemical reactions in natural waters at low temperatures, 0-50°C. The program is capable of mixing waters, equilibrating waters with multiple phases, including gases, and simulating redox reactions. The composition of the water following the reaction, including pH and pe are output.*

Data Requirements: *Chemical analyses for all major constituents in a water. A thermodynamic data set is also necessary but is supplied with the program.*

Computer Costs: *One to two seconds CPU on Amdahl per run. Usually less than $10 per run depending on class.*

Documentation Available: *Yes*

References: *Parkhurst, D. L., Thorstenson, D. C., and Plummer, L. N., 1980, PHREEQE - A computer program for geochemical calculations: U.S. Geological Survey Water-Resources Investigations 80-96.*

Person to Contact for More Information:
Regional Quality-Water Specialists

DUSHRY—Duwamish River Estuary Model

Status: Operational. Card deck exists at Washington district office.

Program Use: Computes salinity, temperature, BOD, DO, chlorophyll a, pH, and coliform concentrations in a salt-wedge type estuary. Program may require modifications when applied to other salt-wedge estuaries.

Data Requirements: Channel geometry, fresh water inflow, tide stage at mouth, location of wedge toe as function of tide stage and fresh-water discharge, upper-layer thickness at mouth, slope of interface, entrainment rates, chemical and biological reaction rates, meteorological data, quality of salt water at mouth, quality of entering fresh water.

Computer Costs: About $2 per prototype day.

Documentation Available: Yes

References: Prych, E. A., Haushild, W. L., and Stoner, J. D., 1976, Numerical model of the salt-wedge reach at the Duwamish River estuary, King County, Washington: U.S. Geological Survey Professional Paper 990, 34 p.

Haushild, W. L., and Prych, E. A., 1976, Modeling coliform bacteria and pH in the salt-wedge reach of the Duwamish River estuary, King County, Washington: U.S. Geological Survey Open-File Report 76-415, 43 p.

Person to Contact for More Information:
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QUAL II—Stream quality model

Status: The program and documentation are complete. The program can be easily adapted to any computer system, and is available on the Johns Hopkins Univ. (APL) computer.

Program Use: The program was designed to assist in making resource decisions concerning receiving waters. The program can analyze the effects of the magnitude and location of point and nonpoint sources. The model simulates any combination of the following for steady flow:

1. Temperature
2. DO
3. BOD
4. NH_3, NO_2, NO_3
5. Phytoplankton
6. PO_4
7. Coliform bacteria
8. One arbitrary nonconservative substance
9. Three arbitrary conservative substances

Options allow a dynamic simulation (for diel variations) of water quality, computation of flow augmentation necessary to maintain prescribed DO levels, and computation of BOD reduction necessary to maintain prescribed DO levels.

Data Requirements: Accurate estimates are needed for depth, velocity, and discharge. For best results, the data collection period should exceed the traveltime in the reach. Data for the constituents modeled should be collected on all tributaries frequently enough to estimate mean loads (1-12 times daily depending on how well the loads can be described as steady). Two independent sets of data are needed to calibrate and confirm the validity of the model. Meteorological data is needed to model temperature.

Computer Costs: $3-$4 per run; $50-$100 per calibration.

Documentation Available: Yes

References: Barnwell, Thomas, 1978, Appendix E, in Holston River Study: Report No. EPA 904/9-78-019, U.S. Environmental Protection Agency, Athens, Ga.

McCutcheon, S. C., 1982, Evaluation of selected one-dimensional stream water-quality models with field data: U.S. Army Waterways Experiment Station, Technical Report, Vicksburg, Miss., in press.

Roesner, L. A., Giguerre, P. A., and Evenson, D. E., 1977, Computer program documentation for the stream quality model QUAL II: Water Resources Engineers, Walnut Creek, Calif.

Person to Contact for More Information:

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Environmental Research Laboratory
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WQRRS—Water quality for river-reservoir systems

Status: Complete; available only on Univ. of California at Berkeley CDC computer system.

Program Use: WQRRS is a dynamic flow and water-quality model for modeling one-dimensional aerobic lakes (vert. stratification) or streams on the order of a day to several months. The simulation includes:

1. Temperature
2. DO
3. BOD
4. Coliform bacteria
5. Detritus
6. NH_3
7. NO_2
8. NO_3
9. PO_4
10. Alkalinity
11. Fish #1
12. Fish #2
13. Fish #3
14. Unit toxicity
15. Zooplankton
16. Total dissolved solids
17. Phytoplankton #1
18. Phytoplankton #2
19. Total inorganic carbon
20. Organic sediment
21. Benthic animals
22. Suspended solids #1
23. Suspended solids #2
24. Suspended solids #3
25. Suspended solids #4
26. Suspended solids #5
27. Inorganic sediment
28. Aquatic insects
29. Benthic algae #1
30. Benthic algae #2

Data Requirements: Data for channel geometry or stage vs. discharge is needed. Initial instream quality data is needed and data for the constituents of interest must be collected frequently enough to describe variations in loads from tributaries. Two independent data sets for tributaries and the stream are needed for calibration and confirmation of the validity of the model. Meteorological data is needed to model temperature.

Computer Costs: $1-$3 per day of simulation; $100-$1,000 per application.

Documentation Available: Yes

References: *McCutcheon, S. C., 1982, Evaluation of selected one-dimensional stream water-quality models with field data: U.S. Army Waterways Experiment Station, Technical Report, Vicksburg, Miss., in press.*

Smith, D. J., 1978, Water-quality for river-reservoir systems: U.S. Army Corps of Engineers Hydrologic Engineering Center Report, Davis, Calif.

Willey, R. C., Abbott, Jess, and Gee, Michael, 1977, Oconee River water quality and sediment analysis: U.S. Army Corps of Engineers Hydrologic Engineering Center Report, Davis, Calif.

Willey, R. C., and Huff, Dennis, 1978, Chattahoochee River water quality analysis: U.S. Army Corps of Engineers Hydrologic Engineering Center Report, Davis, Calif.

Person to Contact for More Information:

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