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## References

1. Akima H (1978a), A method of bivariate interpolation and smooth surface fitting for irregularly distributed data points, *ACM Transactions on Mathematical Software* (4): 148-159
2. Akima H (1978b), Algorithm 526: Bivariate interpolation and smooth surface fitting for irregularly distributed data points, *ACM Transactions on Mathematical Software* (4): 160-164
3. Akin H and Siemes H (1988), *Praktische Geostatistik*, Springer, Berlin Heidelberg New York
4. Alexander M (1994) *Biodegradation and Bioremediation*, Academic Press, San Diego, Calif., 302 pp
5. Andersen PF (1993), A manual of instructional problems for the USGS MODFLOW model. Center for Subsurface Modeling Support. EPA/600/R-93/010
6. Anderson MP (1979), Using models to simulate the movement of contaminants through ground water flow systems. *Critical Reviews in Environmental Control* 9(2): 97-156
7. Anderson MP (1984) Movement of contaminants in groundwater: groundwater transport - advection and dispersion. *Groundwater Contamination: 37-45*. National Academy Press, Washington DC
8. Anderson MP and Woessner WW (1991) *Applied groundwater modeling: simulation of flow and advective transport*. 381 pp. Academic Press, San Diego, CA
9. Ashcraft CC and Grimes RG (1988), On vectorizing incomplete factorization and SSOR preconditioners. *SIAM Journal of Scientific and Statistical Computing* 9(1): 122-151
10. Axelsson O and Lindskog G (1986). On the eigenvalue distribution of a class of preconditioning methods, *Numerical Mathematics* (48): 479-498
11. Baetsle LH (1967), Computational methods for the prediction of underground movement of radio-nuclides. *J Nuclear Safety* (8)6: 576-588
12. Bear J (1972), *Dynamics of fluids in porous media*. American Elsevier Pub. Co., New York.
13. Bear J (1979), *Hydraulics of Groundwater*, McGraw-Hill, N.Y., 569 pp
14. Bear J and Verruijt A (1987), *Modeling groundwater flow and pollution*, D. Reidel Publishing, Dordrecht, Holland
15. Behie A and Forsyth Jr. P (1983), Comparison of fast iterative methods for symmetric systems, *IMA J of Numerical Analysis* (3): 41-63
16. Borden RC and Bedient PB (1984), Transport of dissolved hydrocarbons influenced by oxygen-limited biodegradation, 1, theoretical development, *Water Resour Res* 20, 1973-1982

17. Cheng X and Anderson MP (1993), Numerical simulation of ground water interaction with lakes allowing for fluctuating lake levels. *Ground Water* 31(6): 929-933
18. Chiang WH and Kinzelbach W (1991, 1993), *Processing Modflow (PM)*, Pre- and post-processors for the simulation of flow and contaminant transport in groundwater system with MODFLOW, MODPATH and MT3D. Distributed by Scientific Software Group, Washington, DC
19. Chiang WH (1993), *Water Budget Calculator - A computer code for calculating global and subregional water budget using results from MODFLOW*. Kassel University, Germany.
20. Chiang WH and Kinzelbach W (1994), *PMPATH. An advective transport model for Processing Modflow and Modflow*. Geological Survey of Hamburg, Germany.
21. Chiang WH, Kinzelbach W and Rausch R (1998), *Aquifer Simulation Model for Windows - Groundwater flow and transport modeling, an integrated program*. Gebrüder Borntraeger, Berlin Stuttgart. ISBN 3-443-01039-3
22. Chiang WH, Bekker M and Kinzelbach W (2001) *User guide for three dimensional visualization for MODFLOW-related groundwater flow and transport models*, Institute for Groundwater Studies, University of the Free State, South Africa.
23. Chiang WH and Kinzelbach W (2001), *3D-Groundwater Modeling with PMWIN*. First Edition. Springer Berlin Heidelberg New York. ISBN 3-540 67744-5, 346 pp
24. Chiang WH, Chen J and Lin J (2002), *3D Master - A computer program for 3D visualization and real-time animation of environmental data*. Excel Info Tech, Inc. 146 pp.
25. Clement TP (1997), *RT3D - A modular computer code for simulating reactive multi-species transport in 3-dimensional groundwater systems*. Battelle Pacific Northwest National Laboratory. Richland, Washington 99352
26. Clement TP (2000), *RT3D Version 2.0 - A modular computer code for simulating reactive multispecies transport in 3-dimensional groundwater systems*.
27. Clement TP (2002), *RT3D Version 2.5 - A modular computer code for simulating reactive multispecies transport in 3-dimensional groundwater systems*.
28. Cooper Jr. HH and Rorabaugh MJ (1963), *Ground-water movements and bank storage due to flood stages in surface streams*: U. S. Geological Survey. Water-Supply Paper 1536-J: 343-366
29. Council GW (1999), *A lake package for MODFLOW (LAK2)*. Documentation and user's manual. HSI Geotrans.
30. Davis JC (1973), *Statistics and data analysis in geology*. John Wiley & Sons, New York
31. Deutsch CV and Journel AG (1998), *GSLIB - Geostatistical Software Library and User's Guide*, Second Edition. Oxford University Press. ISBN 0-19-510015-8
32. Doherty J (1990), *MODINV - Suite of software for MODFLOW pre-processing, post-processing and parameter optimization*. User's manual. Australian Centre for Tropical Freshwater Research
33. Doherty J, Brebber L and Whyte P (1994), *PEST - Model-independent parameter estimation*. User's manual. Watermark Computing. Australia
34. Doherty J (2000), *PEST - Model-independent parameter estimation*. User's manual. Watermark Computing. Australia
35. Doherty J (2001a), *MODFLOW-ASP - Using MODFLOW-2000 with PEST-ASP*. Watermark Computing. Australia
36. Doherty J (2001b), *PEST-ASP upgrade notes*. Watermark Computing. Australia
37. Domenico PA (1972), *Concepts and Models in Groundwater Hydrology*, McGraw-Hill, New York, 405 pp
38. Domenico PA and Schwartz FW (1990), *Physical and Chemical Hydrogeology*. John Wiley & Sons, New York., 709 pp

39. Englund E and Sparks A (1991), User's guide of GEO-EAS - Geostatistical environmental assessment software, EPA 600/8-91/008
40. Fenske J P, Leake SA and Prudic DE (1996), Documentation of a computer program (RES1) to simulate leakage from reservoirs using the modular finite-difference ground-water flow model (MODFLOW), U. S. Geological Survey, Open-File Report 96-364
41. Fetter CW (1994), Applied Hydrogeology, 3rd Edition. Macmillan College, New York, 691 pp
42. Franke R (1982), Scattered data interpolation: Tests of some methods. *Mathematics of computation* (38)157: 181-200
43. Freeze RA and Cherry JA (1979), *Groundwater*. Prentice-Hall, Inc. Englewood Cliffs, New Jersey
44. Frenzel H (1995), A field generator based on Mejia's algorithm. Institut für Umweltphysik, University of Heidelberg, Germany
45. Gelhar LW and Collins MA (1971), General analysis of longitudinal dispersion in nonuniform flow. *Water Resour Res* 7(6): 1511-1521
46. Gelhar LW, Mantoglou A, Welty C and Rehfeldt KR (1985), A review of field-scale physical solute transport processes in saturated and unsaturated porous media. EPRI Report EA-4190, Electric Power Research Institute, Palo Alto, CA
47. Gelhar LW, Welty C and Rehfeldt KR (1992), A critical review of data on field-scale dispersion in aquifers. *Water Resour Res* 28(7): 1955-1974
48. Hantush, MS and Jacob CE (1955), Non-steady radial flow in an infinite leaky aquifer, *Trans. Am Geophys Un* 36(11): 95-100
49. Harbaugh, AW (1990), A computer program for calculating subregional water budgets using results from the U.S. Geological Survey modular three-dimensional ground-water flow model: U.S. Geological Survey Open-File Report 90-392, 46 p.
50. Harbaugh AW (1995), Direct solution package based on alternating diagonal ordering for the U.S. Geological Survey modular finite difference ground water flow model: U.S. Geological Survey Open File Report 95 288, 46 pp
51. Harbaugh AW and McDonald MG (1996a), User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model, USGS Open-File Report 96-485
52. Harbaugh AW and McDonald MG (1996b), Programmer's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model, USGS Open-File Report 96-486
53. Harbaugh AW, Banta ER, Hill MC and McDonald MG (2000), MODFLOW-2000, The U.S. Geological Survey modular ground-water model User guide to modularization concepts and the ground-water flow process, U. S. Geological Survey, Open-file report 00-92.
54. Higgins GH (1959), Evaluation of the groundwater contamination hazard from underground nuclear explosives. *J Geophys Res* (64), 1509-1519
55. Hill MC (1990a), Preconditioned Conjugate-Gradient 2 (PCG2), A computer program for solving groundwater flow equations, U. S. Geological Survey, Denver
56. Hill MC (1990b), Solving groundwater flow problems by conjugate-gradient methods and the strongly implicit procedure, *Water Resour Res* 26(9): 1961-1969
57. Hill MC (1992), MODFLOW/P - A computer program for estimating parameters of a transient, three-dimensional, groundwater flow model using nonlinear regression, U.S. Geological Survey, Open-file report 91-484
58. Hill MC (1998), Methods and guidelines for effective model calibration. U.S. Geological Survey, Water-Resources Investigations Report 98-4005

59. Hill MC, Banta ER, Harbaugh AW and Anderman ER (2000), MODFLOW-2000, The U.S. Geological Survey modular ground-water model - User guide to the observation, sensitivity, and parameter-estimation processes and three post-processing programs, U. S. Geological Survey, Open-file report 00-184.
60. Hoschek J and Lasser D (1992), Grundlagen der geometrischen Datenverarbeitung, B. G. Teubner, Stuttgart, Germany
61. Hsieh PA (1986), A new formula for the analytical solution of the radial dispersion problem, *Water Resour Res* 22(11): 1597-1605.
62. Hsieh PA and Freckleton JR (1993), Documentation of a computer program to simulate horizontal-flow barriers using the U. S. Geological Survey's modular three-dimensional finite-difference ground-water flow model. U.S. Geological Survey, Open-File Report 92-477
63. Hunt BW (1978), Dispersive sources in uniform groundwater flow. *ASCE Journal of the Hydraulics Division* 104(HY1), p.75-85.
64. Integrated Environmental Services, Inc. (2003), Web-based Environmental Data Management System. <http://www.iesinet.com>.
65. Javandel I, Doughty C and Tsang CF (1984), Groundwater transport: Handbook of mathematical models, 228 pp. American Geophysical Union
66. Kinzelbach W (1986), Groundwater Modelling - An introduction with sample programs in BASIC. Elsevier. ISBN 0-444-42582-9
67. Kinzelbach W, Ackerer P, Kauffmann C, Kohane B and Miller B (1990), FINEM, Numerische Modellierung des zweidimensionalen Strömungs- und Transportproblems mit Hilfe der Methode der finiten Elemente. Programmdokumentation Nr. 89/23 (HG 111), Institut für Wasserbau, Universität Stuttgart.
68. Kinzelbach W, Marburger M and Chiang WH (1992), Determination of catchment areas in two and three spatial dimensions. *J Hydrol* (134): 221-246
69. Kinzelbach W and Rausch R (1995), Grundwassermodellierung - Einführung mit bungen. Gebrüder Borntraeger, Berlin Stuttgart. ISBN 3-443-01032-6
70. Kipp, KL, Jr. (1986), HST3D-A computer code for simulation of heat and solute transport in three-dimensional ground-water flow systems: U.S. Geological Survey Water-Resources Investigations Report 86-4095, 597 p.
71. Konikow LF and Bredehoeft JD (1978), Computer model of two-dimensional solute transport and dispersion in ground water. U. S. Geological Survey. Water Resources Investigation. Book 7, Chapter C2, 90 pp
72. Konikow LF, Goode DJ and Homberger GZ (1996), A three-dimensional method-of-characteristics solute-transport model. U. S. Geological Survey. Water Resources Investigations report 96-4267
73. Kuiper LK (1981), A comparison of the incomplete Cholesky conjugate gradient method with the strongly implicit method as applied to the solution of two-dimensional ground-water flow equations, *Water Resour Res* 17(4): 1082-1086
74. Leake SA and Prudic DE (1991), Documentation of a computer program to simulate aquifer-system compaction using the modular finite-difference ground-water flow model. U.S. Geological Survey
75. Leonard BP (1979), A stable and accurate convective modeling procedure based on quadratic upstream interpolation. *Computer Methods Appl Mech. Engng* (19)
76. Leonard BP (1988), Universal Limiter for transient interpolation modeling of the advective transport equations: the ULTIMATE conservative difference scheme, NASA Technical Memorandum 100916 ICOMP-88-11

77. Leonard BP and Niknafs HS (1990), Cost-effective accurate coarse-grid method for highly convective multidimensional unsteady flows, NASA Conference Publication 3078: Computational Fluid Dynamics Symposium on Aeropropulsion, April 1990
78. Leonard BP and Niknafs HS (1991), Sharp monotonic resolution of discontinuities without clipping of narrow extrema, *Computer & Fluids*, 19(1): 141-154
79. Li YH and Gregory S (1974), Diffusion of ions in seawater and in deep-sea sediments. Pergamon Press
80. Mathéron G (1963), Principles of geostatistics, *Economic Geology* (58): 1246-1266
81. McDonald MG and Harbaugh AW (1988), MODFLOW, A modular three-dimensional finite difference ground-water flow model, U. S. Geological Survey, Open-file report 83-875, Chapter A1
82. McDonald MG, Harbaugh AW, Orr BR and Ackerman DJ (1991), BCF2 - A method of converting no-flow cells to variable-head cells for the U.S. Geological Survey Modular Finite-Difference Ground-water Flow Model. U.S. Geological Survey, Open-File Report 91-536, Denver
83. Mehl SW and Hill MC (2001), User guide to the Link-AMG (LMG) package for solving matrix equations using an algebraic multigrid solver. U.S. Geological Survey Open-File Report 01-177.
84. Moench AF and Ogata A (1981), A numerical inversion of the Laplace transform solution to radial dispersion in a porous medium. *Water Resour Res*, 17(1): 250-253
85. Neumann SP (1984), Adaptive Eulerian-Lagrangian finite element method for advection-dispersion. *Int. J. Numerical Method in Engineering* (20): 321-337
86. Oakes BD and Wilkinson WB (1972), Modeling of ground water and surface water systems: I - Theoretical relationships between ground water abstraction and base flow: Reading, Great Britain, Reading Bridge House, Water Resources Board (16), 37 pp
87. Parkhurst and Appelo (2000) PHREEQC (Version 2) - A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. U. S. Geological Survey. Water Resources Investigations report 99-4259
88. Pannatier Y (1996), Variowin, Software for spatial data analysis in 2D, Springer, Berlin Heidelberg New York. ISBN 0-387-94679-9
89. Poeter EP and Hill MC (1998), Documentation of UCODE, a computer code for universal inverse modeling, U.S. Geological Survey, Water-Resources Investigations Report 98-4080
90. Pollock DW (1988), Semianalytical computation of path lines for finite difference models. *Ground Water* (26)6: 743-750
91. Pollock DW (1989), MODPATH (version 1.x)- Documentation of computer programs to compute and display pathlines using results from the U. S. Geological Survey modular three-dimensional finite-difference ground-water model. U. S. Geological Survey Open-file report 89-381
92. Pollock DW (1994), User's Guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking post-processing package for MODFLOW, the U. S. Geological Survey finite difference groundwater flow model. U. S. Geological Survey, Open-file report 94-464.
93. Prommer H (2002), PHT3D A multicomponent transport model for three dimensional reactive transport in saturated porous media. Personal communication.
94. Prudic DE (1988), Documentation of a computer program to simulate stream-aquifer relations using a modular, finite-difference, ground-water flow model, U.S. Geological Survey, Open-File Report 88-729, Carson City, Nevada
95. Rausch R (1998), Computer program for the calculation of 1-D and 2-D concentration distribution. Personal communication

96. Renka RJ (1984a), Interpolation of the data on the surface of a sphere. *ACM Transactions on Mathematical Software* (10): 417-436
97. Renka RJ (1984b), Algorithm 624: Triangulation and interpolation at arbitrarily distributed points in the plane. *ACM Transactions on Mathematical Software* (10): 440-442
98. Rifai HS, Bedient PB, Borden RC and Haasbeek JF (1987) *BIOPLUME II - Computer model of two-dimensional contaminant transport under the influence of oxygen limited biodegradation in ground water*, National Center for Ground Water Research, Rice University.
99. Rifai HS, Newell CJ, Gonzales JR, Dendrou S, Kennedy L and Wilson J (1997) *BIOPLUME III, Natural attenuation decision support system, version 1 User's Manual*, Air Force Center for Environmental Excellence, Brooks AFB, San Antonio, Texas
100. Robinson RA and Stokes RH (1965), *Electrolyte Solutions*, 2nd ed. Butterworth, London
101. Saad Y (1985) Practical use of polynomial preconditionings for the conjugate gradient method, *SIAM Journal of Scientific and Statistical Computing*, 6(4): 865-881
102. Scandrett C (1989) Comparison of several iterative techniques in the solution of symmetric banded equations on a two pipe Cyber 205, *Appl Math Comput* 34(2): 95-112
103. Schaars FW and van Gerven MW (1997) Density package, Simulation of density driven flow in MODFLOW. KIWA-report SWS 97.511, ISBN 90-74741-42-8. KIWA Research & Consultancy, Nieuwegein. The Netherlands
104. Seber GAF and Wild CJ (1989) *Nonlinear Regression*, John Wiley & Sons, NY, 768 pp
105. Shepard D (1968), A two dimensional interpolation function for irregularly spaced data. *Proceedings 23rd. ACM126 National Conference*: 517-524
106. Spitz K and Moreno J (1996), *A practical guide to groundwater and solute transport modeling*, 461 pp. John Wiley & Sons, New York. ISBN: 0-471-13687-5
107. Sun NZ (1995), *Mathematical modeling of groundwater pollution*, 377 pp. Springer, Berlin Heidelberg New York.
108. Theil H (1963) On the use of incomplete prior information in regression analysis: *American Statistical Association Journal*, 58 (302): 401-414
109. Travis CC (1978), *Mathematical description of adsorption and transport of reactive solutes in soil: A review of selected literature*. Oak Ridge Natl. Lab. ORNL-5403
110. Trescott PC and Larson SP (1977), Comparison of iterative methods of solving two-dimensional groundwater flow equations, *Water Resour Res* 13(1): 125-136
111. Watson DF (1992), *Contouring - A guide to the analysis and display of spatial data (with programs on diskette)*. Pergamon, ISBN 0-08-040286-0
112. Wexler EJ (1992), *Analytical solutions for one-, two- and three-dimensional solute transport in groundwater systems with uniform flow*. U. S. Geological Survey. *Techniques of Water Resources Investigations, Book 3, Chapter B7*, 190 pp
113. Wilson JD and Naff RL (2004), *The U.S. Geological Survey modular groundwater model - GMG linear equation solver package documentation*. U.S. Geological Survey. Open-File Report 2004-1261.
114. Wilson JL and Miller PJ (1978), Two-dimensional plume in uniform ground-water flow. *J. Hyd Div ASCE*(4): 503-514
115. Zheng C (1990), *MT3D, a modular three-dimensional transport model*, S.S. Papadopoulos & Associates, Inc., Rockville, Maryland
116. Zheng C and Bennett GD (1995), *Applied contaminant transport modeling: Theory and practice*, 440 pp. Van Nostrand Reinhold, New York
117. Zhang Y, Zheng C, Neville CJ and Andrews CB (1995), *ModIME An integrated modeling environment for MODFLOW, PATH3D and MT3D*. S.S. Papadopoulos & Associates, Inc., Bethesda, Maryland

118. Zheng C (1996), MT3D Version DoD.1.5, a modular three-dimensional transport model, The Hydrogeology Group, University of Alabama
119. Zheng C and Wang PP (1999), MT3DMS: A modular three-dimensional multispecies model for simulation of advection, dispersion and chemical reactions of contaminants in groundwater systems; Documentation and Users Guide, Contract Report SERDP-99-1, U.S. Army Engineer Research and Development Center, Vicksburg, MS.
120. Zheng C (1999), MT3D99 A modular 3D multispecies transport simulator, S.S. Papadopulos and Associates, Inc. Bethesda, Maryland
121. Zheng C and Wang PP (2002), MGO A Modular Groundwater Optimizer, The University of Alabama, Alabama.

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