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developed as a transport code with water quality subroutines. After Di Toro (1983) applied the WASP model to simulate nutrient cycling in -- 3.2.2.2 Applicability to Total Maximum Daily Load Studies. The WASP model is widely used in conjunction with other transport hydrodynamic models to simulate complex water quality processes in rivers, lakes, reservoirs, estuaries, and coastal waters.

3.2.3 Environmental Fluid Dynamics Code -- 3.2.3.1 Model

Background and Capabilities. The Environmental Fluid Dynamics Code (EFDC) is a surface water model with hydrodynamic and water quality modeling capabilities. The EFDC model was originally developed at the Virginia Institute of Marine S -- 3.2.3.2 Applicability to Total Maximum Daily Load Studies. The EFDC model has been widely used in more than 100 modeling studies of aquatic ecosystems around the world and in multiple TMDL studies. TMDL applications include the Peconic Bay in New Y -- 3.2.4 CE-QUAL-W2 -- 3.2.4.1 Model

Background and Capabilities. The CE-QUAL-W2 model is a two-dimensional (2D), laterally averaged hydrodynamic and water quality model. The hydrodynamic model capabilities include the simulation of water levels and depths, flow velocities -- 3.2.4.2 Applicability to Total Maximum Daily Load Studies. The CE-QUAL-W2 model has been widely used as a management tool to evaluate effects from various stressors, including temperature, nutrients, and organic loads in waterbodies (Bowen and Hie -- 3.2.5 Hydrologic Engineering Center-River Analysis System -- 3.2.5.1 Model Background and Capabilities. HEC-RAS is a 1D and 2D hydraulic and water quality model for riverine ecosystems developed by the USACE Hydrologic Engineering Center (HEC). HEC-RAS is an extensively used model worldwide designed to perfor -- 3.2.5.2 Applicability to Total Maximum Daily Load Studies.

The HEC-RAS water quality model has been used to support TMDLs and environmental impact statement studies. Recent studies include the lower Minnesota River (Zhang and Johnson 2014), Misso -- 3.2.6 Center for Computational Hydroscience and Engineering-1D/2D/3D.

3.2.6.1 **Model Background and Capabilities.** The numerical models CCHE-1D/2D/3D have been developed by the National Center for Computational Hydroscience and Engineering at the University of Mississippi. This development was supported by the USDA Agri -- 3.2.6.2 Applicability to Total Maximum Daily Load Studies. CCHE-1D/2D/3D models are applicable to TMDL studies for nutrients, sediment, toxic chemicals in channel networks, rivers, lakes, and coastal waters. The CCHE-1D model has been applied to si -- 3.2.7 Environmental Protection Division-RIV1 -- 3.2.7.1 Model Background and Capabilities. The EPD-RIV1 model is a 1D, cross-sectional-averaged, hydrodynamic, and water quality model for rivers and streams. The EPD-RIV1 model was originally developed for the Georgia Environmental Protection Divis -- 3.2.7.2 Applicability to Total

Maximum Daily Load Studies. The EPD-RIV1 model can be used in 1D river systems subject to dynamic hydrodynamics. EPD-RIV1 provides time-varying simulations of water temperature and water quality with a primary focus o -- 3.2.8 QUAL2K -- 3.2.8.1 Model Background and Capabilities. The QUAL2K model is a 1D water

quality model for river and stream networks. The model is based on the algorithms and routines originally included in the QUAL2E model with improvements in the representation -- 3.2.8.2 Applicability to Total Maximum Daily Load Studies. QUAL2K has been used to support WLAs and TMDL studies of rivers and streams. Typical applications are related to pollution caused by pathogens, excess nutrients such as nitrogen and phospho -- 3.2.9 MINTEQA2 and Visual MINTEQ.

3.2.9.1 **Model Background and Capabilities.** The MINTEQA2 model (

Allison et al. 1991) is a geochemical equilibrium-speciation model for the fate and transport of metals in aqueous systems. MINTEQA2 and Visual MINTEQ simulate the equilibrium and mass -- 3.2.9.2 Applicability to Total Maximum Daily Load Studies. Simulation of the fate and transport and speciation of dissolved metals, free metal ions, sorbed metals, metal precipitates, and metal complexes is a difficult task. Speciation is driven by -- 3.2.10 One-Dimensional Transport with Equilibrium Chemistry -- 3.2.10.1 Model Background and Capabilities. The One-Dimensional Transport with Equilibrium Chemistry (OTEQ) model is a reactive transport model that simulates the fate and transport of solutes and speciation and transport of metals in rivers and str -- 3.2.10.2 Applicability to Total Maximum Daily Load Studies. OTEQ can be applied to support TMDLs and WLA studies related to the fate and transport of metals in rivers and streams. The model has been previously used to support the evaluation of reme -- 3.2.11 MIKE 11 -- 3.2.11.1 Model Background and Capabilities. MIKE 11 is a River Hydraulics and Sediment Transport model developed by the Danish Hydraulic Institute (DHI) Water and Environment which is currently in the MIKE+ platform (DHI 2021). The MIKE 11 model h -- 3.2.11.2 Applicability to Total Maximum Daily Load Studies. MIKE 11 is typically linked to ECO-Lab for water quality studies involving eutrophication of waterbodies, nutrient transport and cycling, and to support TMDL projects (e.g., Liang et al. -- 3.3 State-of-the-Art and State-of-the-Practice -- References -- Book_5114_C004 -- Chapter 4 : Integrated Modeling Systems and Linked Models -- 4.1 Introduction -- 4.2 Integrated Modeling Systems -- 4.2.1 BASINS Modeling System. 4.2.1.1 BASINS Model Releases. The BASINS version 1 was released in 1996 and consisted of various data sets (e.g., land use, water quality, digital elevation, river reach network, streamflow, and meteorological data), models such as HSPF, QUAL2E, an.

Sommario/riassunto

MOP 150 provides detailed descriptions of several watershed and receiving water quality models used in total maximum daily load (TMDL) analysis and modeling, highlighting recent advancements in TMDL development and implementation.