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Application of 3D numerical model THREETOX to the prediction of cooling water transport and mixing

R. Bezhenar (1), **I. Brovchenko** (1), R. Heling (2), H. Jenner (3), A. Kuschan (1), V. Koshebutskyy (1), V. Maderich (1), K. Terletska (1)

(1) Ukrainian Center for Environmental and Water Projects, Kiev, Ukraine, (2) NRG, Arnhem, Netherlands, (3) KEMA, Arnhem, Netherlands (vladmad@gmail.com / Fax: +38 044-5263615 / Phone: +38 044-5266187)

Industries using large quantities of cooling water are obliged to predict the possible thermal effects on the water bodies on which the discharge takes place to prevent damage to the aquatic environment. A comprehensive modeling system - THREETOX - has been developed by joint efforts of Dutch and Ukrainian companies to simulate the cooling water transport and mixing in inland waters and coastal seas. The 3D hydrostatic free-surface model describes the heat dispersion in the far - field, whereas the non-hydrostatic model (Kanarska, Maderich, 2003) is applied to the near - field. The equations of hydrodynamics are completed by the heat and salt transport equations and $k - \epsilon$ model of turbulence. Special attention is devoted to the parameterization of heat fluxes between water and atmosphere, between water and the sediments including effects of bottom vegetation on the heat and momentum fluxes. Also wetting and drying related with tides and floods was parameterized for shallow estuaries. The numerical solution was carried out using a double vertical sigma coordinate system. An orthogonal curvilinear horizontal grid with nesting capabilities was used to accurately describe the area of interest. The advective terms in the equations for the scalar function are approximated by high order schemes. To conduct simulations with high resolution computational grids, code parallelization was realized.

Such model with detailed description of water transport, and water mixing and of air-water energy exchange is an appropriate tool to predict the dispersion of cooling water discharges, in different aquatic systems (cooling ponds, lakes, rivers, estuaries, canals, tidal harbours, and coastal areas) in critical situations. It is a appropriate support tool in the design phase of factories as for determining the optimal location and config-

uration of the conduits (inlet / outfall) to minimize recirculation, to avoid exceeding the maximum allowed temperatures in the ambient water, as for reducing the transfer of heat to the inlets of other factories in the vicinity. For companies such model is an obligatory tool for assessment studies focused on environmental thermal effects of cooling water discharges on the surface waters, either for the evaluation of their activities in EIS, or for acquisition of the permit.

The modeling system has been successfully applied in large number of projects for the evaluation of present and future cooling water discharges in the Netherlands and Belgium among which the Port of Rotterdam, the Port of Antwerp, the Ems-Estuary, the North Sea Canal and the Amsterdam-Rhine Canal, the lakes Markermeer and Ijsselmeer, and the rivers Rhine and Meuse.