

EEMS Demonstration Model Description

DM_West_Lakes_Toxics

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate hydrodynamics, temperature, cohesive and non-cohesive sediment transport, and three toxic contaminants in West Lake (Hô Tây), Hanoi, Vietnam (latitude $\approx 21^\circ$ N). The model was originally developed by DSI for demonstrating a shallow lake simulation integrating all major water quality and sediment–contaminant interaction modules in EFDC+.

The model captures wind-driven circulation, thermal stratification, suspended sediment dynamics, and the fate and transport of three contaminants — Pesticides, Polychlorinated Biphenyls (PCBs), and Zinc (Zn) — in both the water column and the sediment bed across a 90-day warm-season simulation period.

2 Model Description

The model configuration is summarized in Table 1 and the model domain is shown in Figure 1. The domain represents the shallow, crescent-shaped West Lake with bottom elevations ranging from 3 m to 5 m (above datum). The simulation spans 90 days from 2009-03-06 to 2009-06-04, with a nominal time step of 2 s and a dynamic maximum of 3,600 s.

Table 1 Model configuration summary

Run Period (days)	Horizontal Cells	Vertical Layers	Activated Modules
90(2009-03-06 to 2009-06-04)	5,060 cells	• 3 equal water column layers • 4 sediment bed layers	• Hydrodynamics • Temperature • Sediment Transport • Chemical Fate and Transport • Wave model

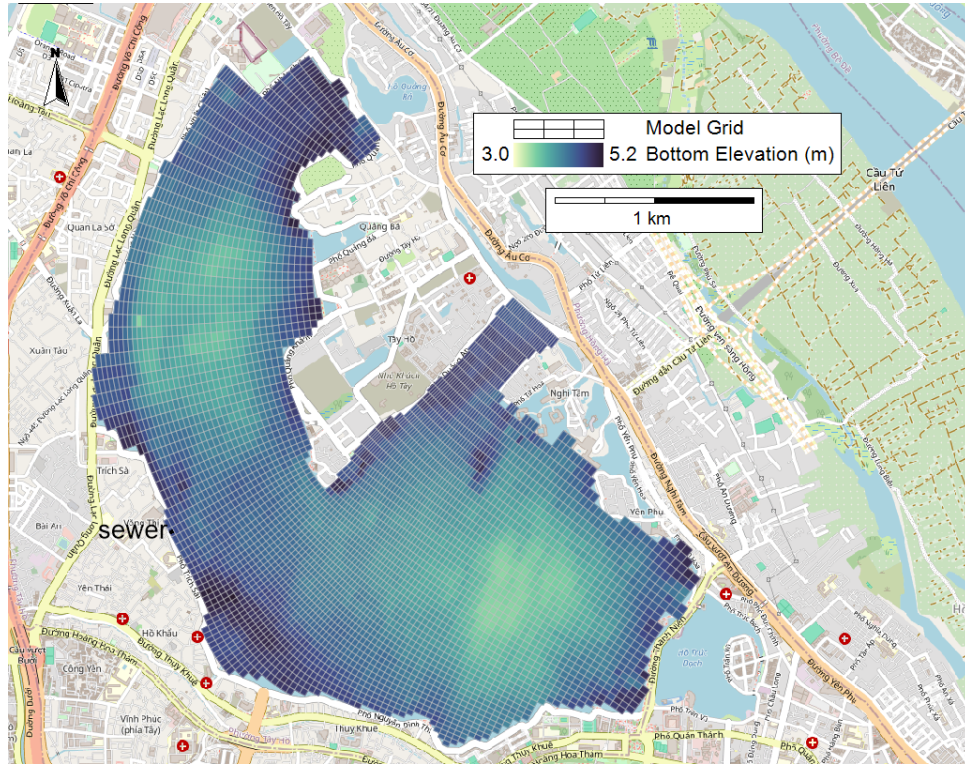


Figure 1 Model domain of West Lake, Hanoi, Vietnam

2.1 Hydrodynamic and Thermal Configuration

The model uses a two-time-level integration scheme on a curvilinear grid with 3 equal sigma layers and Mellor–Yamada 2.5 turbulence closure for vertical turbulence calculations. Horizontal momentum diffusion is activated. Wetting and drying is activated with a minimum depth of 0.02 m and a wet threshold of 0.04 m. Coriolis forcing is applied at latitude 21° N ($CORIOLIS = 5.225 \times 10^{-5} \text{ s}^{-1}$). The internally computed wave model is activated.

Atmospheric forcing includes a single wind time series and atmospheric heat exchange data, *Atmospheric.dat*) driving the thermal budget. Temperature transport is active, with full surface heat exchange.

Eight time-series flow boundary conditions represent inflows and outflows at named locations around the lake perimeter, all driven by the same flow time series (*Flow.dat*, series 1) with spatially varying temperature (*Temperature.dat*, series 1) and toxics (*Toxic.dat*, series 1) concentrations:

ID	Name	Cell (I, J)
1	Tay Ho Hotel	44, 112
2	Trich Sai	9, 94
3	Thang Loi Hotel	59, 35
4	Thanh Nien	51, 5
5	Ly Tu Trong	30, 10
6	Quang Ba	40, 119
7	Cong Do	6, 61
8	Giay TB	—

2.2 Sediment Transport Configuration

Both cohesive and non-cohesive sediment transport are active. One cohesive sediment class is simulated: initial water column concentration 50 mg/L, initial bed mass 10 g/m², specific volume $3.774 \times 10^{-7} \text{ m}^3/\text{g}$, specific gravity 2.65, settling velocity 0.001 m/s, and critical shear stress

for deposition 0.01 Pa. Resuspension uses the Sanford and Maa approach with resuspension rate $0.01 \text{ g/m}^2/\text{s}$, critical shear stress for erosion 0.15 Pa, and exponent 0.5.

Two non-cohesive sediment size classes are simulated, both with specific gravity 2.65, initial water column concentration 50 mg/L , and initial bed mass 12 g/m^2 . Class 1 has grain diameter $4 \times 10^{-5} \text{ m}$ and settling velocity 0.00144 m/s ; Class 2 has grain diameter $2.5 \times 10^{-4} \text{ m}$ and settling velocity 0.0351 m/s . The sediment bed uses 4 layers with the SEDZLJ framework.

2.3 Toxics Configuration

Three toxic contaminants are simulated, with properties summarized in Table 2. All contaminants use K_d partitioning (equilibrium), have no kinetic decay, and interact with all three sediment classes (1 cohesive + 2 non-cohesive). Initial water column concentrations range from 0.05 to $0.3 \text{ } \mu\text{g/L}$, and initial bed concentrations are approximately half the water column values. Boundary inflow concentrations for all three contaminants are specified via `Toxic.dat`.

Table 2 Toxic contaminant parameters

Parameter	Pesticides	PCBs	Zinc
Contaminant index (NT)	1	2	3
Initial water column conc. ($\mu\text{g/L}$)	0.30	0.10	0.05
Initial bed conc. ($\mu\text{g/L}$ equivalent)	0.20	0.05	0.025
Sorption model (ISTOC)	POC-based (2)	POC-based (3)	K_d (0)
Water diffusion coeff. (m^2/s)	1×10^{-9}	1×10^{-9}	1×10^{-9}
Bed diffusion coeff. (m^2/s)	2×10^{-8}	2×10^{-8}	1×10^{-8}
Pore-water diffusion factor	1×10^{-5}	1×10^{-4}	1×10^{-6}
WC partition coeff., K_d (L/mg)	0.00291	0.000983	6.2×10^{-5}
Bed partition coeff., K_d (L/mg)	0.0218	0.00737	7.0×10^{-5}
Decay kinetics	None	None	None

3 Folder Structure

The model package contains the following components:

- **Model:** The complete EFDC+ model project directory, loadable directly in EFDC+ Explorer for pre- and post-processing.
- **Data:** Input data organized into two subfolders:
 - *Bathymetry:* West Lake Bathymetry Data 2009.p2d, West Lake Outline.p2d
 - *Boundaries:* Atmospheric.dat, Cohesive Sediments.dat, Flow.dat, Non-cohesive Sediments.dat, Polygon1.p2d–Polygon3.p2d, Temperature.dat, Toxic.dat
- **Grid:** Westlake.cvl (CVL grid format for EE), Westlake.kml (viewable in Google Earth).
- **Maps-Images:** Geo-referenced imagery of the study area.

4 Model Results

Figures 2, 3, and 4 show plan-view snapshots of depth-averaged temperature, total suspended sediments (TSS), and bed zinc (Zn) concentration respectively, at day 0. Figures 2, 3, and 4 show plan-view snapshots of depth-averaged temperature, total suspended sediments (TSS), and bed zinc (Zn) concentration respectively, at day 90, the final day of the simulation.

By the end of the simulation, depth-averaged temperature ranges from 31°C to 34°C across the domain (Figure 2), consistent with the transition into the pre-monsoon warm season in Hanoi. The narrower northwestern arm of the lake, near Quang Ba and Trich Sai, shows the warmest temperatures, while the broader southeastern basin near Thanh Nien and Ly Tu Trong remains comparatively cooler, likely reflecting the moderating influence of boundary inflows in that area. Depth-averaged TSS has declined from the initial water column concentration of 50 mg/L to a nearly uniform 6–7 mg/L across the domain (Figure 3). This reduction is consistent with the low-energy, wind-driven circulation of the shallow lake, in which the specified cohesive and non-cohesive settling velocities allow the initial suspended sediment load to settle out of the water column over the 90-day simulation, reaching a quasi-equilibrium suspended sediment concentration.

Bed Zn concentration (all layers) is likewise close to a uniform equilibrium value across most of the domain, ranging from 0.022 to 0.028 mg/kg (Figure 4), consistent with Zn's simple K_d -partitioning formulation and the absence of decay kinetics. A localized area of elevated bed Zn concentration is present near the Cong Do inflow in the southwestern portion of the lake, consistent with boundary-driven contaminant loading at that location.

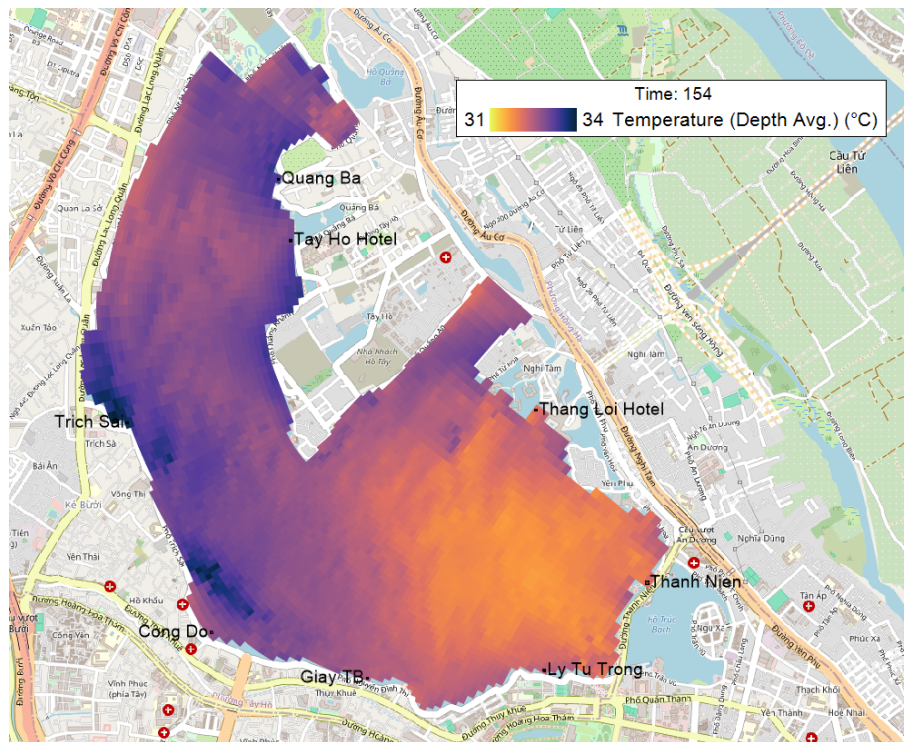


Figure 2 Plan-view depth-averaged temperature in °C, at the end of simulation.

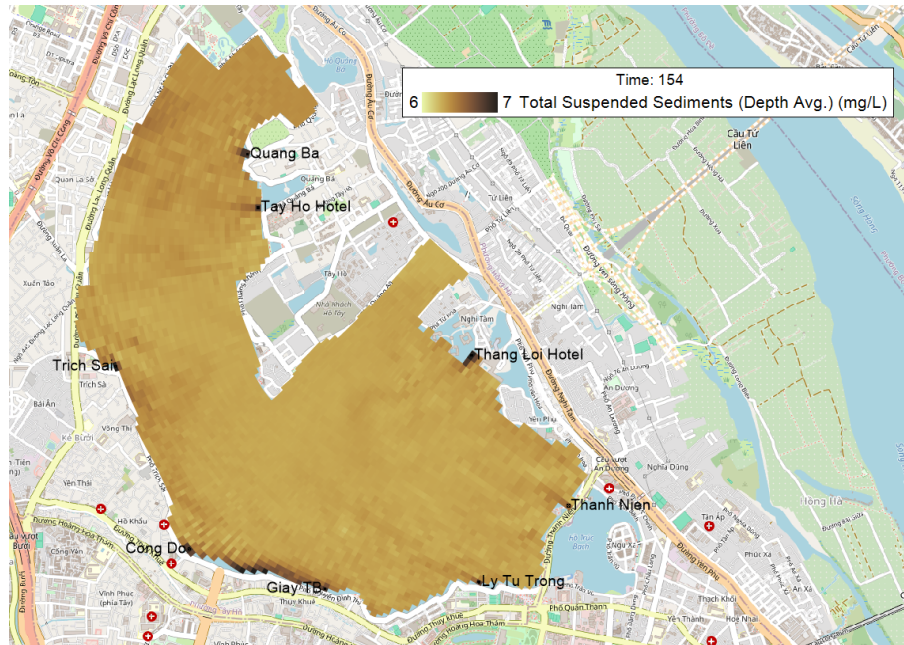


Figure 3 Plan-view depth-averaged TSS in mg/L, at the end of simulation.

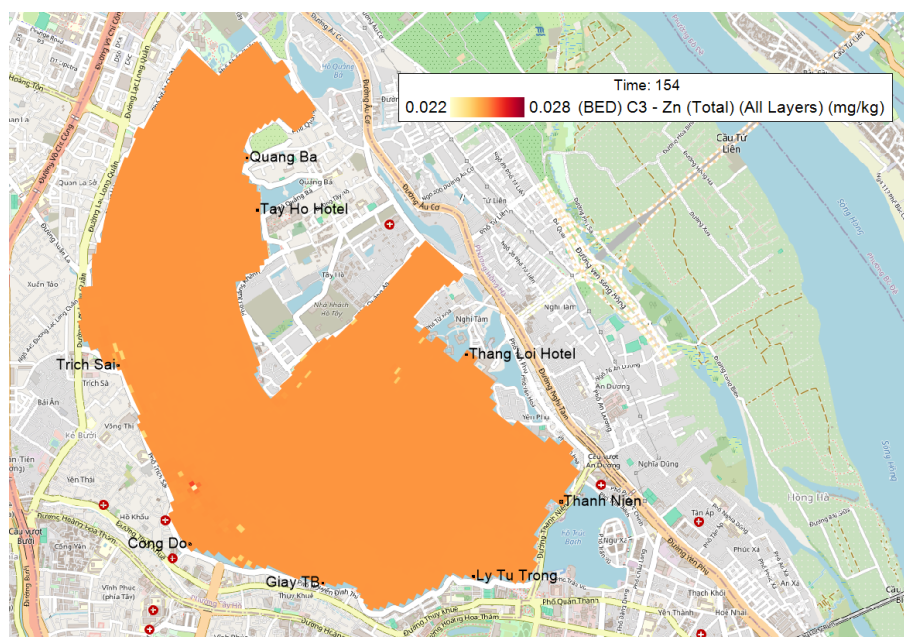


Figure 4 Plan-view bed Zn concentration (all layers) in mg/kg, at the end of simulation.

5 Notes

5.1 Disclaimer

This model is provided to demonstrate that EFDC+ Explorer and EFDC+ can be used to build and analyze this type of models. The simulation results are consistent with expected behavior; however, the model should not be considered a final or validated product. Users are encouraged to review, modify, and refine model parameters to obtain results appropriate for their specific application.

5.2 EEMS Demo Mode

In Demo mode, the model is validated against a set of predefined signatures, including grid size, domain area, center coordinates, transport count, and module configuration. While certain parameter values may be adjusted, the grid cannot be modified, transports cannot be added, and the prescribed module setup cannot be altered. Any deviation from these conditions results in the model no longer being considered a valid demo model.

5.3 Support

For technical support, additional documentation, or to obtain the latest version of EFDC+ Explorer, please visit: www.eemodelingsystem.com