

EEMS Demonstration Model Description

DM_Ohio_River_Storm_Surge_Impact

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate hydrodynamics and conservative dye transport in a reach of the Ohio River near Cincinnati, Ohio. The model was originally developed by DSI for demonstrating how dye can be configured as a tracer in a river model and for comparing results between single-layer (depth-averaged) and four-layer (3D) model configurations.

Dye is released from Mill Creek ($I = 62$, $J = 7$), a lateral tributary inflow on the south bank of the river. The two sub-models share the same grid, boundary conditions, and dye source configuration, differing only in the number of vertical layers and the turbulence closure approach, allowing the influence of vertical resolution on dye transport and water surface elevation predictions to be directly assessed.

2 Model Description

The shared model configuration is summarized in Table 1 and the model domain is shown in Figure 1. The domain represents a sinuous reach of the Ohio River with bottom elevations ranging from 121 m to 137 m (NAVD). The simulation spans 50 days starting from Julian day 350 through day 400, with a nominal time step of 10 s and a dynamic maximum of 3,600 s.

Table 1 Shared model configuration summary

Run Period (Julian time)	Horizontal Cells	Vertical Layers	Activated Modules
350-400	510 cells	1 layer (EFDC.Model_01) 4 layers (EFDC.Model_04)	- Hydrodynamics - Dye

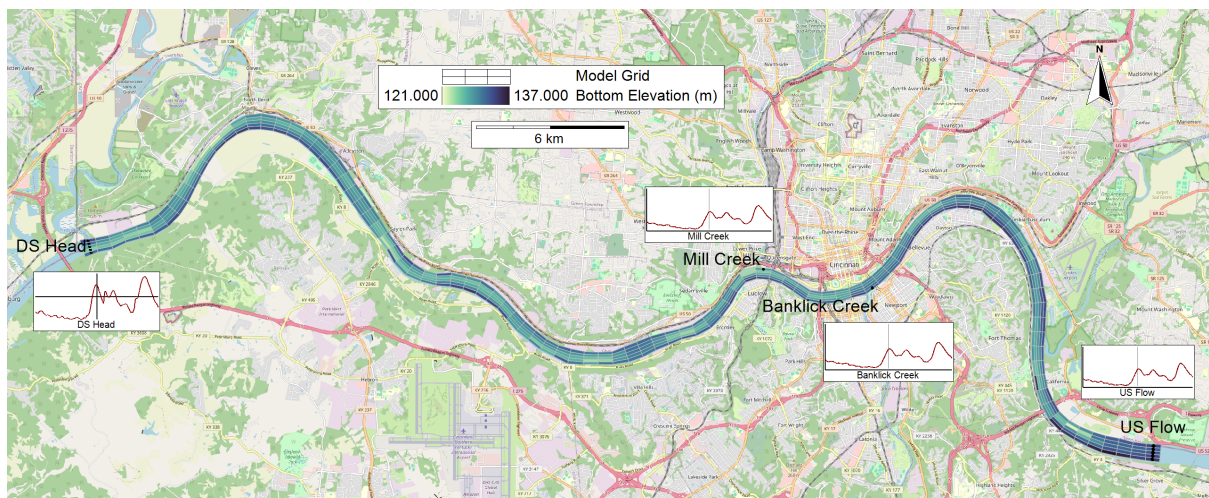


Figure 1 Model domain showing the sinuous Ohio River reach

2.1 Shared Hydrodynamic Configuration

Both sub-models use a two-time-level integration scheme on a curvilinear Cartesian grid with 510 active cells with Coriolis forcing at latitude 39° N ($CORIOLIS = 9.172 \times 10^{-5} \text{ s}^{-1}$). Horizontal momentum diffusion is activated. No wetting and drying is applied.

Boundary conditions consist of a time-series upstream inflow distributed across five cells at the eastern face ($I = 104$, $J = 3-7$, **Cincinnati Flows_TS.dat**) and a time-series downstream water surface elevation (head) boundary at four cells on the western face ($I = 3$, $J = 3-6$, **DS Head.dat**). Two additional lateral inflows are configured: Banklick Creek ($I = 70$, $J = 3$) and Mill Creek ($I = 62$, $J = 7$), both driven by the same upstream flow time series (series 2) with appropriate flow fractions.

2.2 Dye Transport Configuration

One dye tracer class is simulated. Dye is released exclusively from Mill Creek ($I = 62$, $J = 7$), which is assigned dye concentration time series 1, **Mill Creek.Dye.dat**) with a flow fraction of 0.002. The upstream and Banklick Creek inflows carry zero dye concentration. The dye is treated as conservative (no decay). Figure 2 shows the dye time series used.

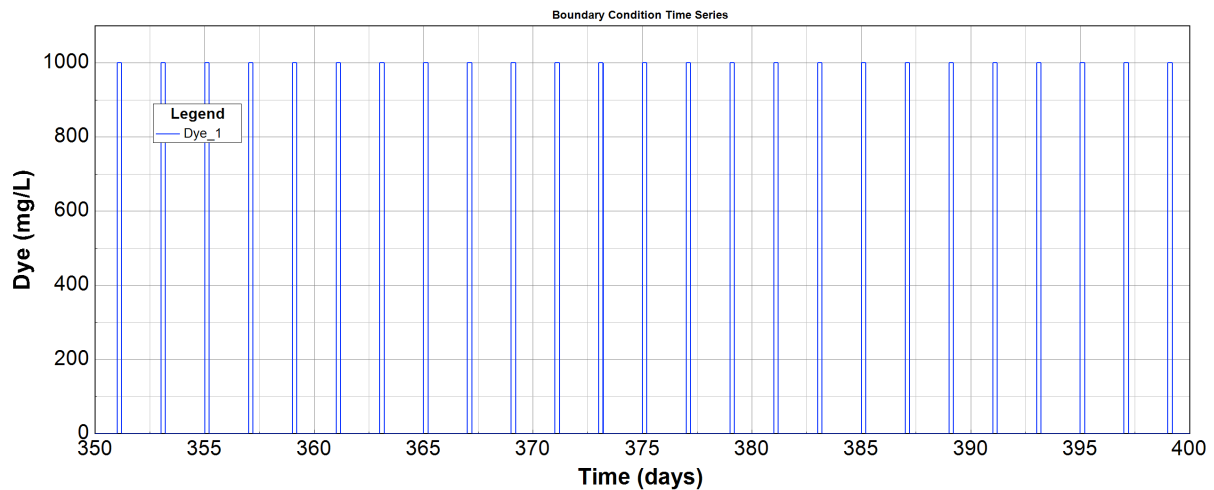


Figure 2 Dye time series

2.3 Sub-Model Vertical Configurations

The two sub-models differ only in vertical discretization and turbulence closure, as summarized in Table 2.

Table 2 Sub-model vertical configurations

Sub-model	Layers	Turbulence	Description
EFDC_Model_01	1 (depth-averaged)	None	Single-layer, depth-averaged simulation. Vertical mixing is implicit; dye is uniformly distributed over the water column depth.
EFDC_Model_04	4 (sigma)	EFDC+ Original Mellor–Yamada	Four equal sigma layers (each 25% of local depth). Mellor–Yamada 2.5 turbulence closure resolves vertical shear and stratification, allowing depth-varying dye transport to be simulated.

3 Folder Structure

The model package contains the following components:

- **EFDC_Model_01:** EFDC+ model project directory for the single-layer configuration.
- **EFDC_Model_04:** EFDC+ model project directory for the four-layer configuration.
- **Data:** Input data shared across both sub-models, organized into three subfolders:
 - *Bathymetry:* `Bottom Elevation.dat`
 - *Boundaries:* `Cincinnati Flows.TS.dat`, `DS Head.dat`, `Mill Creek.Dye.dat`
 - *Calibration:* `Cincinnati Gage Location.dat` (UTM coordinates of the Cincinnati Gage), `Cincinnati Gage_WSEL.dat` (measured water surface elevation at the Cincinnati Gage for model calibration), `Mill Creek.Dye.dat`
- **Grid:** `OhioR.cvl` (CVL grid format for EE), `OhioR.kml` (viewable in Google Earth).
- **Maps-Images:** Geo-referenced imagery of the study area (`OhioRiver.jpg`, `OhioRiver.jgw`).

4 Model Results

Figure 3 shows the plan-view depth-averaged dye concentration field at Julian day 371.25 from the single-layer (EFDC_Model_01). Figure 4 shows the modeled water surface elevation (WSE) time series from both sub-models compared against Cincinnati Gage observations at Cell 170 ($I = 69$, $J = 4$) over the full 50-day simulation period.

The 2DH dye field (Figure 3) shows the plume originating from the Mill Creek inflow on the south bank of the Ohio River near downtown Cincinnati. At day 371.25, elevated dye concentrations (up to 3 mg/L) are visible extending westward from the Mill Creek source, confined largely to the southern portion of the channel cross-section immediately downstream of the injection point, before gradually spreading laterally as the plume advects through successive river bends toward the downstream boundary.

The WSE calibration comparison (Figure 4) covers the full 50-day run and includes both Model-01 and Model-04 against the Cincinnati Gage observations at Cell 170 ($I = 69$, $J = 4$). Both models produce almost identical WSE predictions throughout the simulation, confirming that vertical resolution does not materially affect the depth-averaged water surface in this river reach. The models capture the general shape and timing of the observed hydrograph well, including the two minor flood pulses near days 353–357 (WSE ≈ 141.5 – 142 m), the pre-flood recession trough near day 365 (WSE ≈ 139.4 m), and the major flood peak near day 370. Both models slightly overpredict the observed peak WSE of approximately 142.8 m by ≈ 1 m.

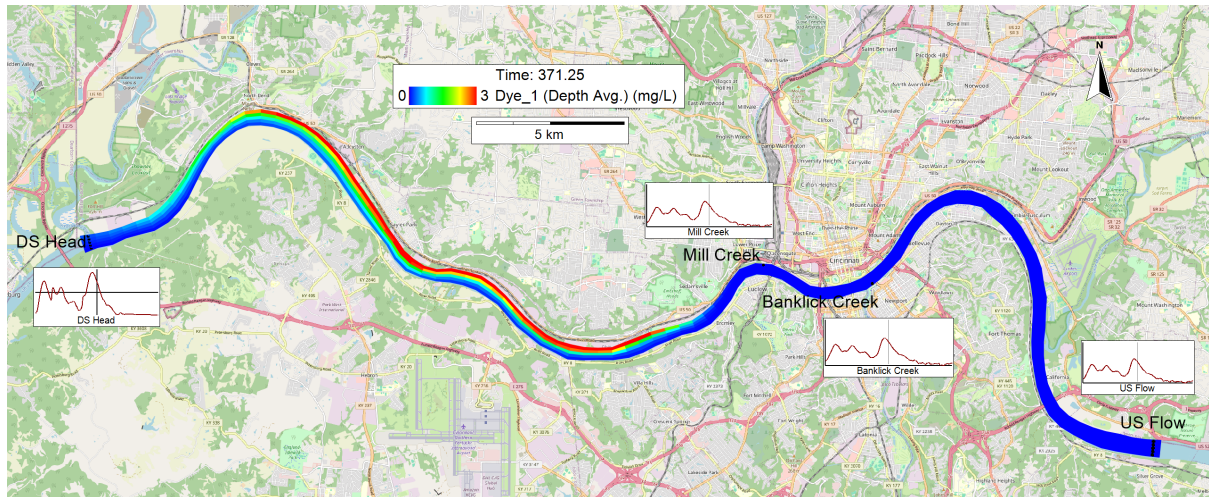


Figure 3 Plan-view depth-averaged dye concentration at Julian day 371.25 from the single-layer model

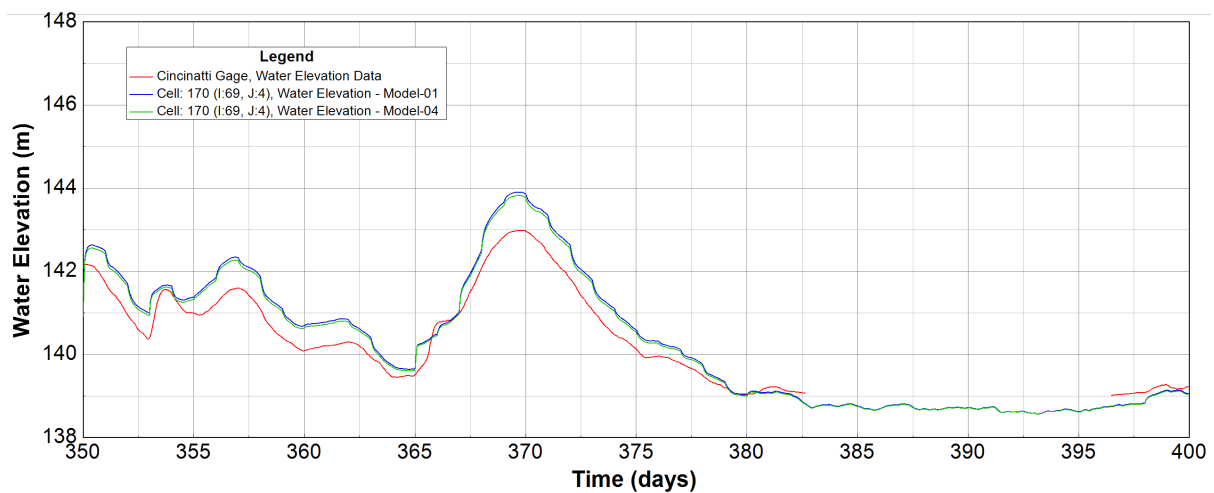


Figure 4 Water surface elevation (m) at Cell 170 (I = 69, J = 4) over Julian days 350–400 for EFDC.Model_01, EFDC.Model_04, and the Cincinnati Gage observations

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