

EEMS Demonstration Model Description

DM_RuleBasedStructures

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate the hydrodynamics of a tidally influenced waterbody when time-series or water-level controlled sluice gates and pumps are introduced as hydraulic structure boundary conditions. The model was originally developed by DSI for testing the rule-based hydraulic structure boundary condition in EFDC+.

Four sub-models are included in this demonstration package, each sharing the same grid and boundary forcing but differing in how the gate or pump structure is controlled. Together they allow a direct comparison of the hydrodynamic response under uncontrolled, time-series, rule-based, and pump-based structure configurations.

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 tidal estuary connected to an upstream river channel through a sluice gate structure, with bottom elevations ranging from -7 m to -2 m. All four sub-models share a 4-day simulation period.

Table 1 Shared model configuration summary

Run Period (Julian time)	Horizontal Cells	Vertical Layers	Activated Modules
0-4	895 cells	• 1 layer	• Hydrodynamics

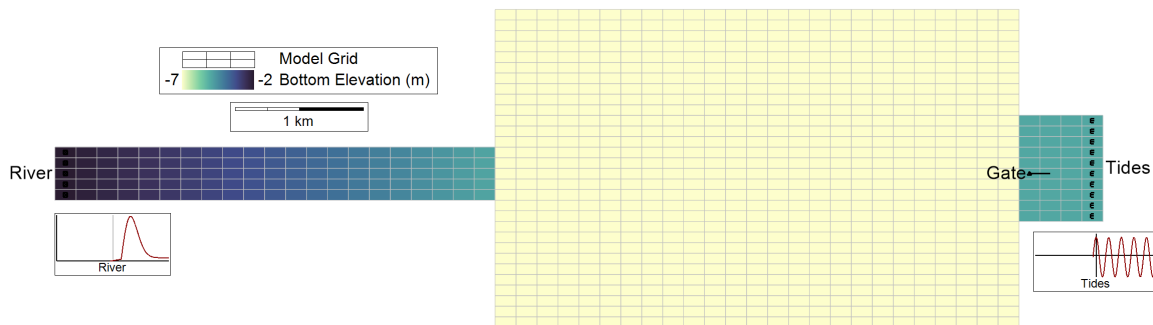


Figure 1 Model domain showing the tidal estuary and upstream channel connected through the hydraulic structure at $I = 49-50$, $J = 17$

2.1 Shared Hydrodynamic Configuration

All four sub-models use a two-time-level integration scheme on a single-layer grid with 895 active cells. Wetting and drying is activated using variable depth cell-face masking with a nominal dry depth of 0.05 m and a wet threshold of 0.10 m.

Boundary conditions consist of a time-series river inflow distributed across five cells at the west face ($I = 3$, $J = 15-19$, **River.dat**) and a time-series tidal water surface elevation applied across ten cells at the east face ($I = 52$, $J = 13-22$, **Tides.dat**).

2.2 Sub-Model Configurations

The four sub-models differ in their hydraulic structure control approach, time step, and structure type, as summarized in Table 2. The sluice gate geometry is identical across the three gate-based sub-models: 20 m wide, 10 m tall, with upstream and downstream invert elevations both at -4 m, located between $I = 49$ (upstream) and $I = 50$ (downstream) at $J = 17$, with reverse flow permitted and discharge coefficients of 1.05 (super-critical weir), 0.61 (sub-critical weir), 0.60 (free sluice), and 0.80 (submerged orifice).

Table 2 Per sub-model configuration details

Sub-model	Control type	Time step	Description
01.Uncontrolled	Uncontrolled	$dt_{\max} = 10$ s	Conventional sluice gate always fully open Initial gate state: open (height = 10 m, width = 20 m, sill = 0 m)
02.Sluice.Time.Series	Time-series	$dt_{\max} = 3,600$ s	Gate opening fraction is prescribed by an external time series read from <code>qctlser.inp</code> , driven by Gate Opening TS.dat
03.Sluice.Control.Rules	Differential WSE rules	$dt_{\max} = 3,600$ s	Gate is opened and closed by a rule based on the water surface elevation difference between the upstream ($I = 49$, $J = 17$) and downstream ($I = 50$, $J = 17$) reference cells defined in <code>qctrules.inp</code>
04.Pump	Withdrawal/return rule	$dt_{\max} = 3,600$ s	No physical sluice gate structure. A pump is simulated via a withdrawal/return boundary condition withdrawing from cell ($I = 49$, $J = 17$) and returning to cell ($I = 50$, $J = 17$), with flow governed by a control rule in <code>qctrules.inp</code>

Figure 2 illustrates the gate discharge time series at the structure location for sub-models 01, 02, and 03 over the full 4-day simulation. The tidal periodicity is clearly visible in all three, with discharge oscillating in response to the alternating flood and ebb tidal forcing at the eastern boundary. The uncontrolled gate passes the full tidal signal without restriction, producing the widest discharge envelope and maintaining flow continuously throughout each tidal cycle (0–510 m^3/s). The time-series gate tracks the uncontrolled response closely during open periods but drops abruptly to near zero during prescribed closure intervals, producing sharp rectangular cutoffs in the discharge record. The control-rules gate exhibits similar closure behavior but with the gate responding directly to the upstream–downstream water surface elevation difference; its discharge profile closely follows the time-series gate during most tidal cycles, confirming that the prescribed time series and the rule-based logic produce comparable gate operation under the ambient tidal forcing of this demonstration model. Note that sub-model 04 (pump) is excluded from this figure as it does not use a sluice gate structure and its discharge is not directly comparable to a gate flow.

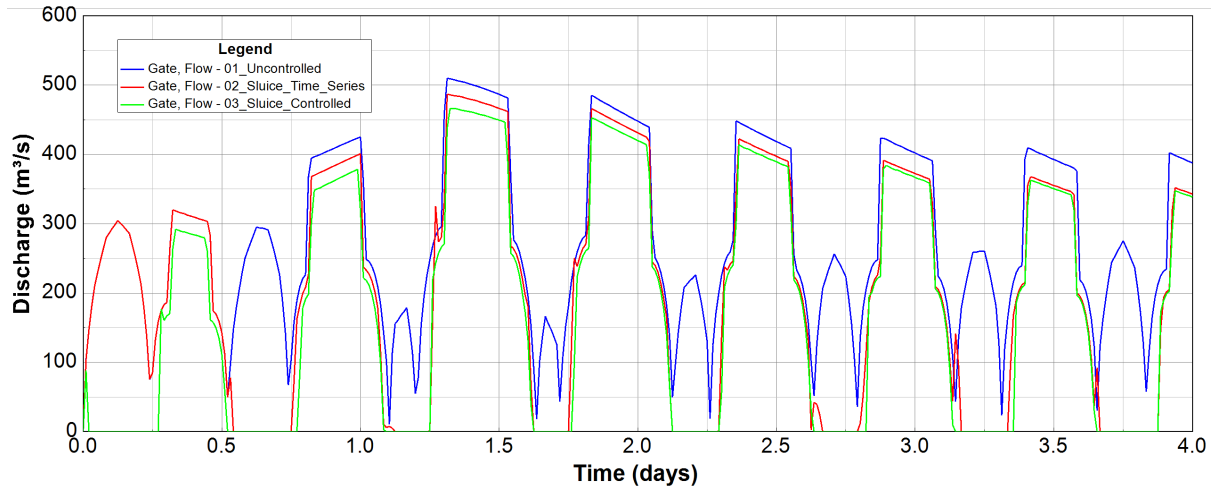


Figure 2 Gate discharge time series (m^3/s) at the hydraulic structure location ($I = 49\text{--}50$, $J = 17$) for sub-models over the 4-day simulation. Sub-model 04_Pump is excluded as it uses a withdrawal/return boundary rather than a gate structure.

3 Folder Structure

The model package contains the following components:

- **Models:** Four EFDC+ model project directories, each loadable directly in EFDC+ Explorer for pre- and post-processing: 01_Uncontrolled, 02_Sluice_Time_Series, 03_Sluice_Control_Rule, and 04_Pump.
- **Data:** Input data shared across sub-models, organized into three subfolders:
 - *Bathymetry:* Bathymetry.dat
 - *Boundaries:* Gate Opening TS.dat, River.dat, Tides.dat
 - *Polyline:* XS01.LDB–XS07.LDB (cross-section polylines for flux line extraction)
- **Grid:** Grid.cvl
- **Reference:** Rule_Based_Structure_Control_Summary_(2018-04-17).pdf — a technical summary of the rule-based control configuration.

4 Model Results

Figure 3 shows the depth-averaged flow time series at Cell 431 ($I = 24$, $J = 17$), located at the junction between the upstream river channel and the entrance to the wider tidal estuary basin, for all four sub-models over the 4-day simulation.

The most notable feature of this comparison is the near-perfect agreement among all four sub-models throughout the entire simulation. Despite fundamental differences in gate control strategy and structure type. This result demonstrates that the choice of hydraulic structure control mode has negligible influence on the flow field at the channel–estuary junction, with the dominant signal being the river inflow hydrograph and its interaction with the tidal boundary rather than the downstream control strategy.

Three distinct phases are evident in all four sub-models. During the initial period (days 0–0.5), flows are low and tidally oscillating between approximately 0 and $30 \text{ m}^3/\text{s}$, reflecting the combined influence of the tidal boundary and low antecedent river discharge. The flood pulse arrives near day 0.75, driving a rapid rise to a peak of approximately $140 \text{ m}^3/\text{s}$ at day 1.0. The

recession thereafter is gradual (days 1.0–2.0), with flow declining to a post-flood tidal baseflow of approximately 10–30 m³/s that persists through day 4.0, superimposed with regular tidal oscillations of roughly 10–20 m³/s amplitude. These results confirm that the EFDC+ rule-based hydraulic structure module correctly implements all four control configurations and that the channel–estuary junction response is robust and consistent regardless of the downstream structure control approach applied.

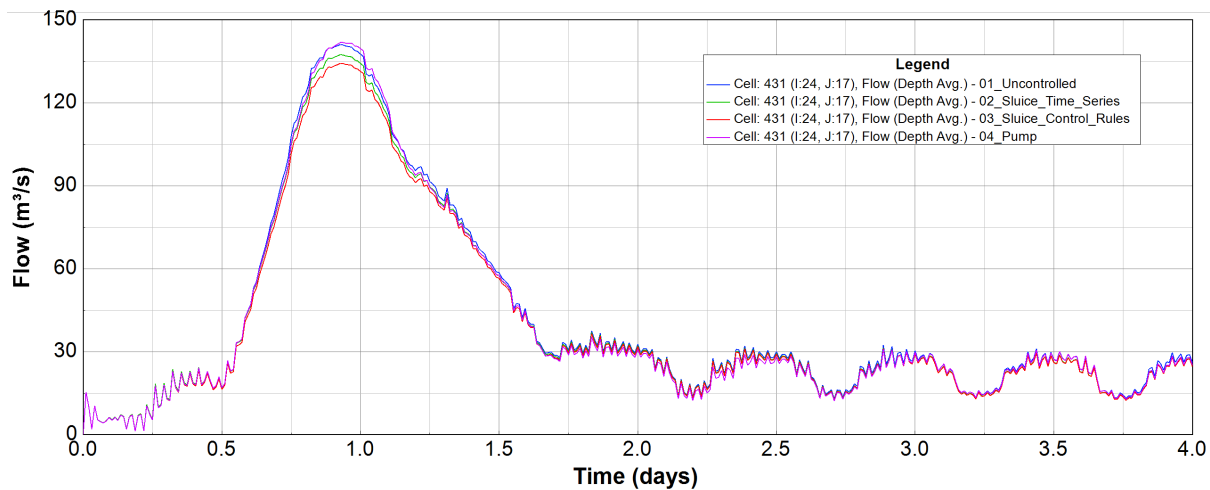


Figure 3 Depth-averaged flow (m³/s) at Cell 431 (I = 24, J = 17) in the upstream channel for all four sub-models over the 4-day simulation

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