Example: Adjustable Gate with Depth Control

This example illustrates how to model an adjustable bypass gate with ITM-SWMM operated to avoid a downstream storage tank from overflowing. The sewer network, shown in Figure 1, consists of six sections of 4.3 m (14 ft) diameter pipe that extending for 3.5 km (2.2 miles) with an elevation drop of 4 m (13 ft) that empties into a 6,000 cubic meter (1.6 million gal) storage tank that is 3 m (10 ft) in height. The full ITM-SWMM input for this example can be found in the ITM-SWMM_Gate_Control.inp file that accompanies this report.

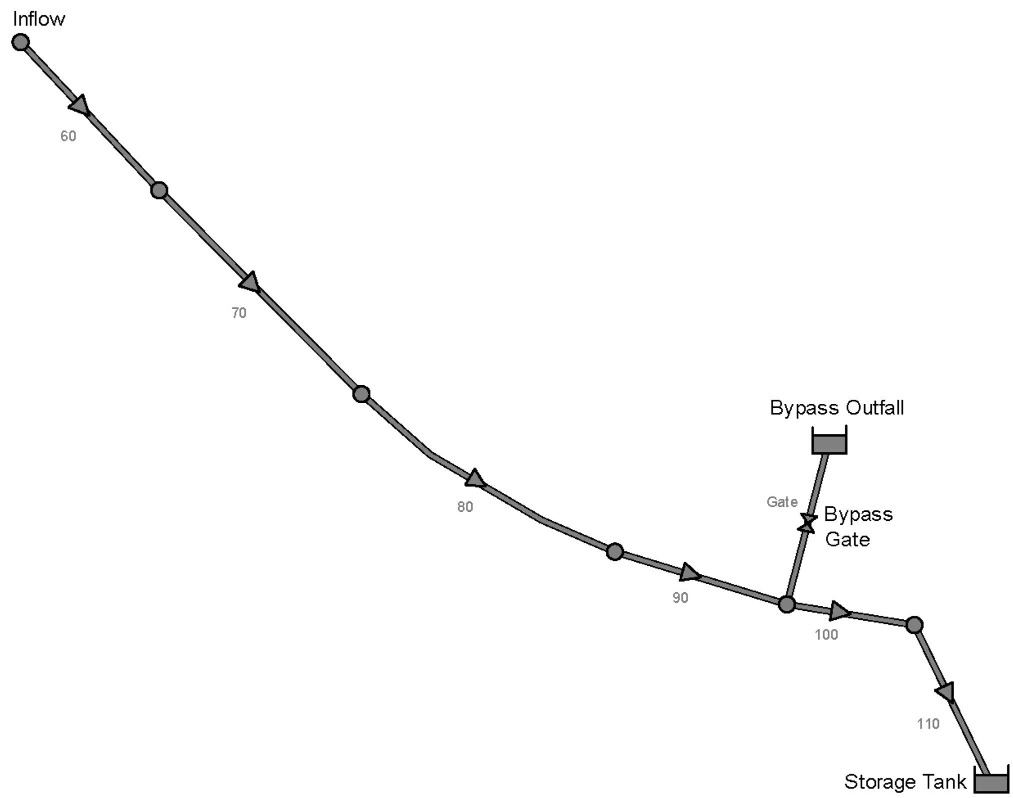

Figure 1. Layout of the Example Sewer System

The bypass gate is represented in ITM-SWMM by a 3 m (10 ft) wide weir with no offset from the invert of its upstream node when fully open. We wish to implement a control strategy that adjusts the open/closed state of the gate so that the Storage Tank fills completely without overflowing under the design inflow hydrograph shown in Figure 2.

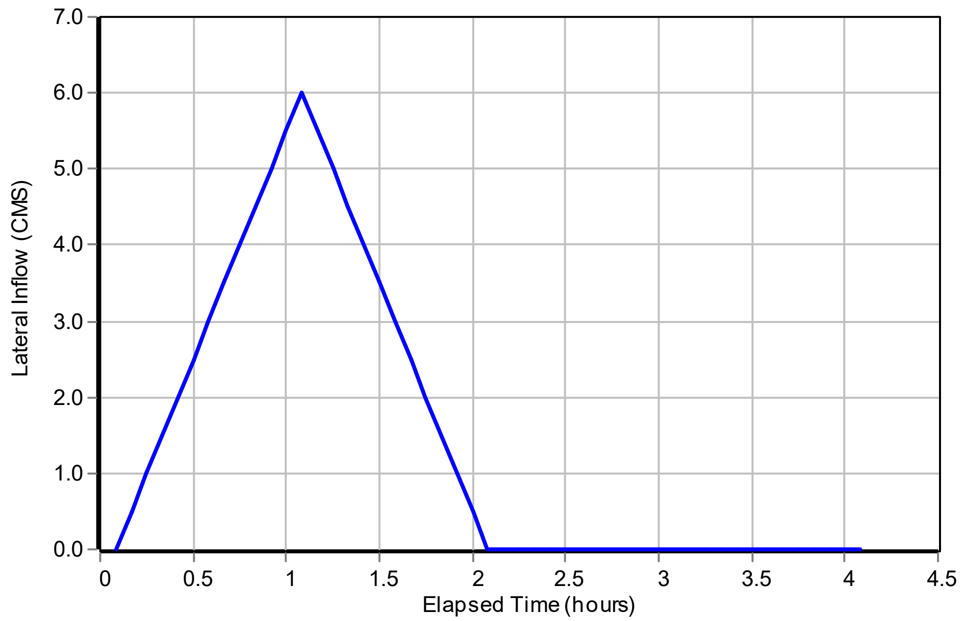

Figure 2. Design Inflow Hydrograph

If the gate was permanently closed the resulting time series of water depth and overflow (i.e., flooding in SWMM-ITM) from the Storage Tank would look as shown in Figure 3.

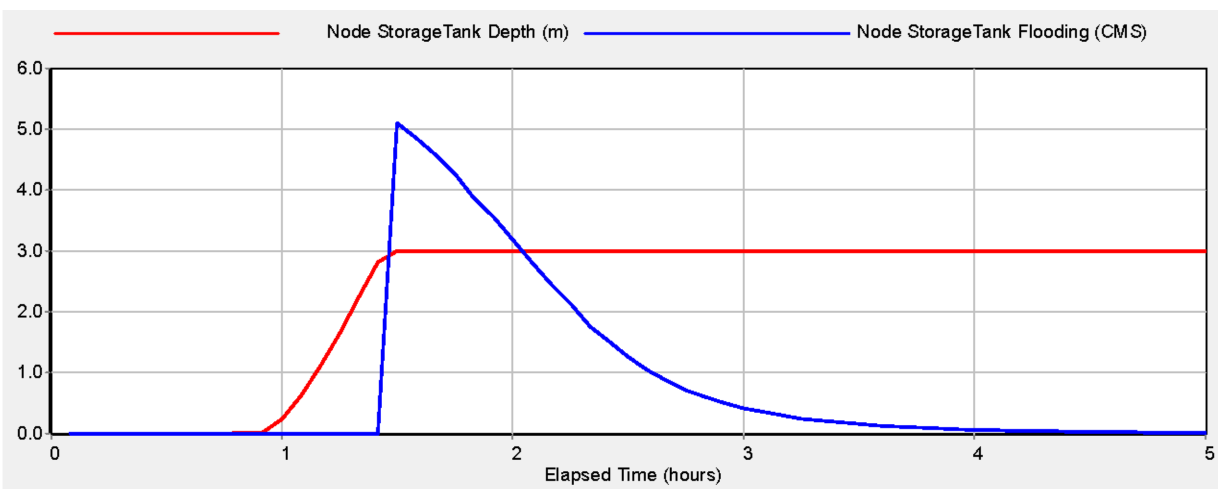

Figure 3. Simulation Results for the Storage Tank with the Bypass Gate Closed

We see that once the water level in the tank reaches its maximum level of 3 m all subsequent inflow becomes overflow. By comparison, if the bypass gate was left completely open then the Storage Tank would behave as shown in Figure 4. This option avoids the tank from overflowing but doesn't allow the tank to fill completely.

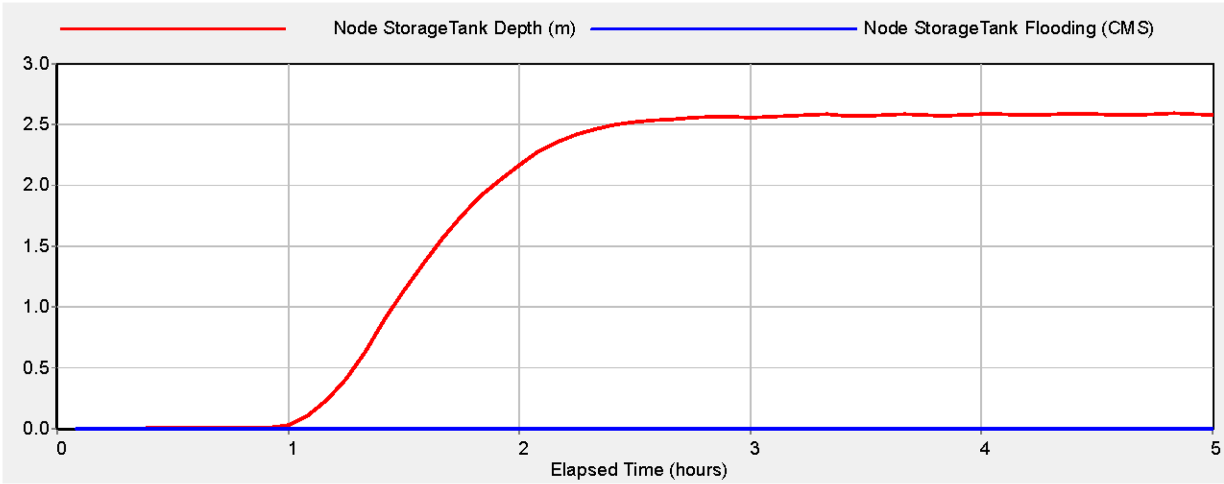

Figure 4. Simulation Results for the Storage Tank with the Bypass Gate Open

The opening of the gate needs to be delayed so that more flow can enter the tank before bypassing begins. This can be accomplished by defining a Control Curve that keeps the gate closed until the Storage Tank reaches a particular level, after which it is opened. Figure 5 shows how such a Control Curve is defined and assigned to the Bypass Gate in ITM-SWMM. The Controller Value is the **water depth** in the **Storage Tank** while the **Control Setting** is the **fraction that the Gate is open**. The cutoff depth of 0.5 m was determined by trial and error. (Please note that the previous two options of gate always closed or always open would be implemented by setting the Weir Gate's Control Method to NONE and its Initial Setting to 0 or 1, respectively.)

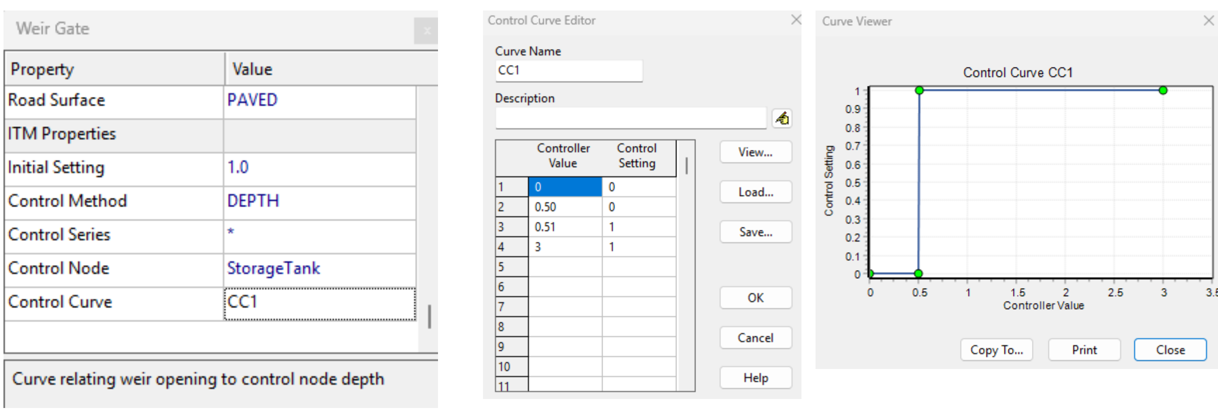

Figure 5. Defining a Control Curve for the Bypass Gate Weir

As shown in Figure 6, this control strategy accomplishes the goal of filling the Tank without any spillage. Table 1 compares the flow volumes that wind up as tank storage, tank overflow and gate bypass flow for the three options simulated. We see that the volume bypassed under the controlled gate option is approximately equal to the tank overflow volume when the gate is kept closed, with both options completely filling the tank. Under the open gate option, the additional 1,200 m^3 of bypass volume prevents the tank from becoming full.

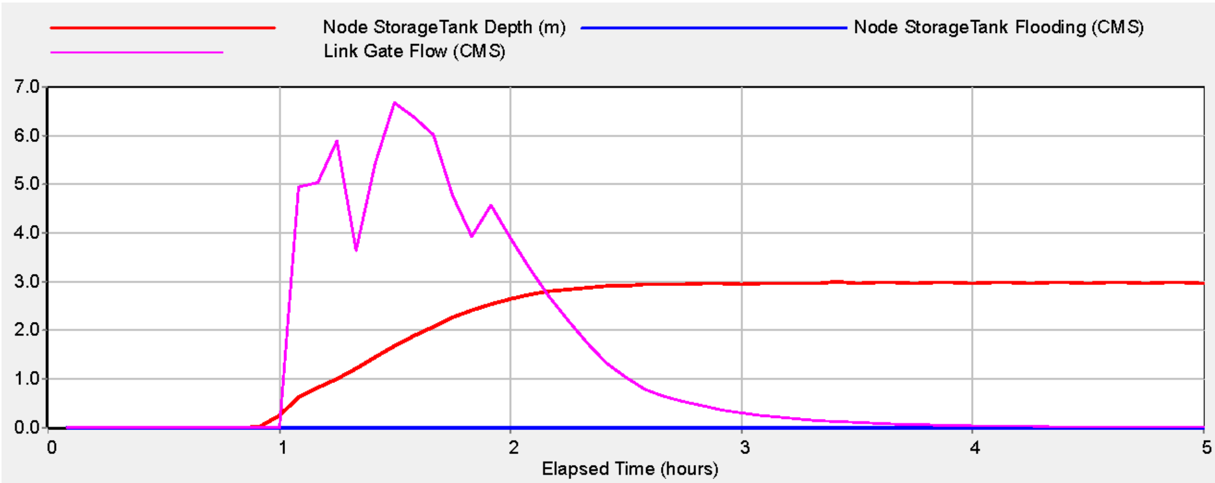

Figure 6. Simulation Results for the Storage Tank with the Control Curve Applied to the Bypass Gate

Table 1. Comparison of Final Flow Volumes

	Final Volume (1000 m^3)		
	Closed Gate	**Open Gate**	**Controlled Gate**
Storage Tank	6	5.18	5.97
Tank Overflow	14.35	0	0
Gate Bypass	0	15.56	14.44