Build-up and wash-off of contaminant from an urban catchment

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In this example we will build a model to simulate the build-up and wash-off of a hypothetical pollutant. For the simulation A 30m×30m square shaped catchment descritized into a 3×3 grid is considered. Table 1 shows the parameters of the model. The model can for example represent a squared shaped parking lot. For the sake of simplicity, no infiltration or evaporation over the catchment has been considered.

Table 1: Parameters of build-up/wash-off example

parameter	value
Area of the catchment	$30m \times 30m$
Build-up rate constant, k_{bld}	$2mg/m^2day$
Saturation build-up concentration, C_{bsat}	$10mg/m2$
Slope of the catchment	0.01 in both directions

Steps to create the build-up and wash-off example:

1. **Add a constituent:** Right-click on on **Project Explorer→Water quality→Constituents** and click on **Add constituent**. Change the name of the constituent to **Pb**.

2. **Creating the build-up object:** Right-click on **Project Explorer→Water quality→Build-ups** and click on **Add build-up**. Set the following properties for the block that was just added:
   - **Accumulation rate:** 2
   - **Model:** Exponential
   - **Constituent:** Pb
   - **Sorbed/attached:** Yes
   - **Saturation:** 10
   Note: Setting **Sorbed/attached** to yes indicates that the built-up Pb will be accumulated as sorbed to the solid phase (in this case pavement surface). So solid-water exchange parameters for Pb needs to be adjusted to let the sorbed Pb to be released into the overland flow during rain events.

3. **Add a catchment block:** From the top tool bar click on the **Add catchment** bottom ![icon]. Set the following properties for the catchment block:
   - **Area:** $100m^2$

- **Build-up:** *Build-up*
- **Manning's roughness coefficient:** $0.011 sm^{-1/3}$.
- **Length:** 10m
- **Width:** 10m

Note: The **width** and **length** properties of a **Catchment** block will be used to assign length and width to the connectors that will be generated as a result of creating an array.

4. **Create an array of catchments:** Right-click on the catchment block and click on **Make array of blocks**. Change **number of rows** and **number of columns** to the value of 3. Also enter a value of -0.3 into **Total bottom elevation change in x direction** and **Total bottom elevation change in y direction**. Change the values of **Horizontal distance between cells in y direction** and **Horizontal distance between cells in x direction** to 10m. Click Ok.

5. **Precipitation:** We will use a previously prepared precipitation input file (precipitation.txt) saved in the example folder. Make sure to download the precipitation file and save it somewhere on your hard-drive. - From **Project Explorer→Settings→Climate Setting** select "precipitation.txt" as the **Precipitation time-series** value.
   - Right-click on the box where the name of the precipitation input file is written and click on **flow** from the drop-down menu. A graph similar to what is shown in Fig 1 will pop-up.

6. **Duration of simulation** Our duration of simulation will cover a portion of the period for which precipitation data is available. From **Project Setting→Project Setting** set the start date of the project to **Sep 01 2012** and the end date to **Oct 01 2012**.

7. **Adding a Receiving water pond:** In order to impose the down stream boundary condition correctly and also to keep track of the runoff volume and pollutant load leaving the catchment a pond will be added to the model and will be connected to the lowest catchment (lower-right) block. Add a pond and move it to the lower right side of the screen. Then connect it to the lower right catchment block (Figure 2).

Assign the following properties to the pond block:
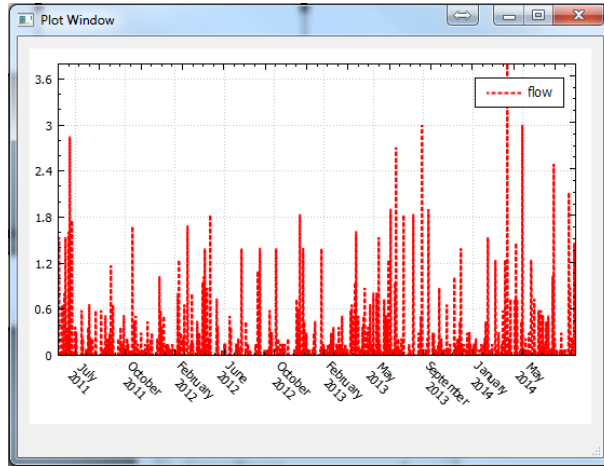-**Area:** $1000 m^2$

Figure 1: Precipitation time series for the build-up example

-**Bottom Elevation:** $-1m$
-**Precipitation:** *No.*

The reason for the last setting is to prevent precipitation to enter the pond in order to be able to use the pond's storage to keep track of runoff volume.

Assign the following properties to the connector connecting **Catchment (9)** to **Pond (1)**:
- **Manning's roughness coefficient:**
- $0.011sm^{-1/3}$
- **Width:** $10m$
- **Length:** $5m$

8. Save the model and run it. After the simulation is done, check the hydraulic and water quality results by right-clicking on blocks or connectors (Figure 3).

9. Right-click on one of the catchment blocks and click on **Plot water quality results→Sorbed/particle associated→Pb→Soil** to see the temporal variation of Pb accumulated on the surface. The results should look like Figure 4. As it can be seen the concentra-
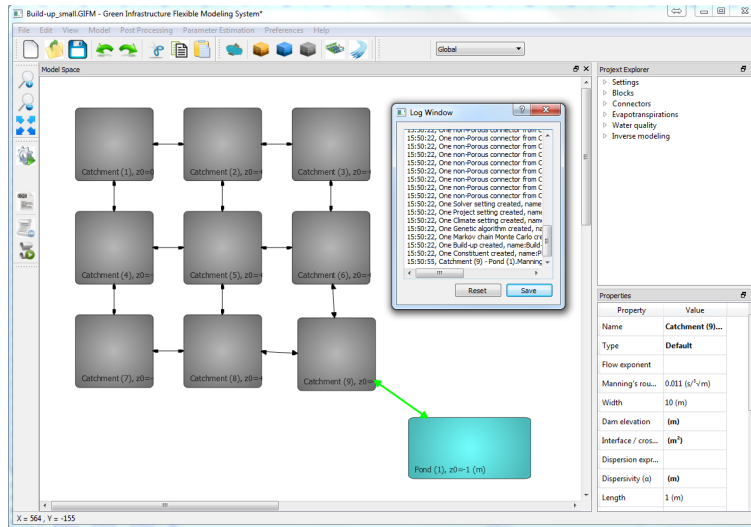
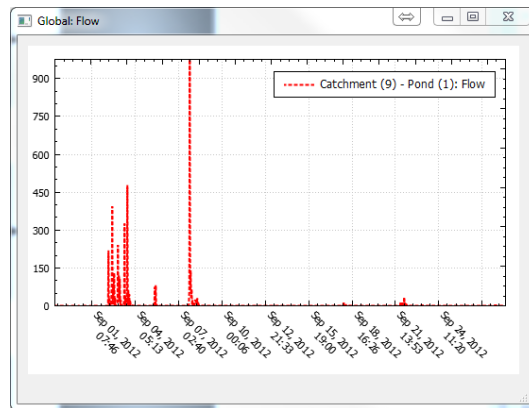Figure 2: Catchment and pond diagram for the build-up, wash-off example

Figure 3: Runoff rate leaving the catchment

tion asymptotically approach $10mg/m^2$. The concentration of Pb in the runoff is zero due to the fact that no release properties have been attributed to Pb.

10. **Setting solid-water exchange properties:** To set solid-water exchange properties for Pb, click on **Water Quality→Constituents→Pb**
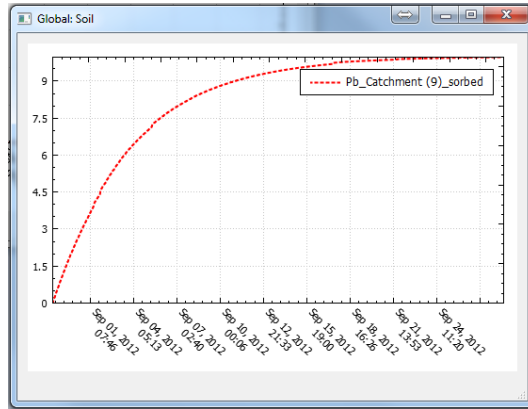
Figure 4: Concentration of Pb accumulated on the surface for the case when solid-water exchange is inactive

from the project explorer and then click on **Exchange rate** from the **Properties** menu. In the table, select **Soil** in the first column and type 0.1 as the exchange rate and 0.01 for the partitioning coefficient. This indicates that the release rate constant for the exchange between solid phase and aqueous phase is $0.1day^{-1}$ while the equilibrium partition coefficient S/C is $0.01m^2/m^3$ (Figure 5). Close the dialog.
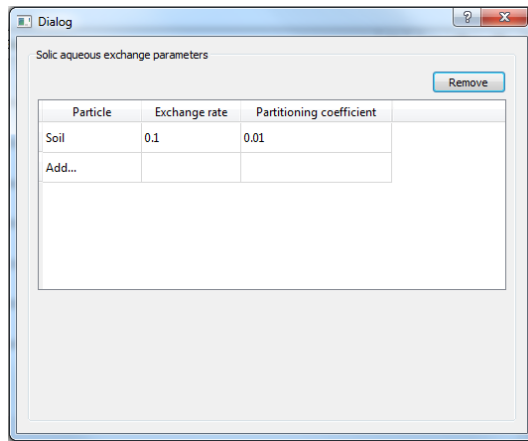

Figure 5: Entering exchange properties

11. Run the model again.

12. Right-click on one of the blocks to see the concentration of Pb in the runoff and the sorbed Pb concentrations. The results should look like Figure 6.
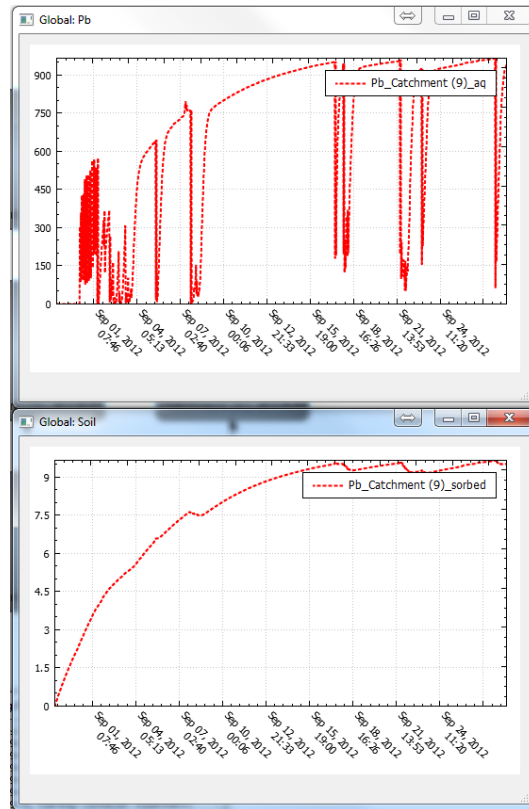

Figure 6: Aqueous phase (top) and surface-bound (bottom) Pb in **Catchment (9)** block