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CITY DRAIN

INTEGRATED URBAN DRAINAGE

TUTORIAL

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tirol STADT INNSBRUCK

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CITY DRAIN 1.0 – an open source Matlab/Simulink library for integrated simulation of urban drainage systems. (2005)

Software requirements:	MATLAB Release 12 (or higher)
Program Language:	Matlab / Simulink
Program Size:	~17 MB
Availability:	*http://umwelttechnik.uibk.ac.at/*

The software is a freeware and may be downloaded at *http://umwelttechnik.uibk.ac.at/*. A copy may as well be obtained by contacting the Institute of Environmental Engineering.

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Disclaimer

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an open source Matlab/Simulink library for integrated simulation of urban drainage systems.

CONTENT

1 INSTALLATION OF CITY DRAIN

City Drain requires two simple steps prior being available within Matlab/Simulink environment. Following files are part of the City Drain software:

CityDrain01.zip
CD1_startup.m
CD1_A_UserManual.pdf
CD1_B_Tutorial.pdf

The file (*CityDrain01.zip*) contains the software library and all associated. Data is to be unzipped and saved preferably in the operating system's programs directory.

C:\Programme\CityDrain01	for German operating system
C:\Program Files\CityDrain01	for English operating system

All functions of City Drain are provided with the prefix *"CD1_"* to avoid conflicts with other Matlab libraries or functions used. For convenient use of City Drain 1.0 it is required to include the *CityDrain01* directory (and all subdirectories) in the Matlab paths. Therefore the Matlab "startup.m" file is extended for automatic adding of City Drain directory to the Matlab path.

File:
C:\Programme\MATLAB6p5\work\startup.m

In case there is no startup.m file created in your Matlab, please create a new startup-file. Following code to be added can be found in *CD1_startup.m.* The user may modify the path of City Drain included in the code (bold printed).

```
% Path setting for CITY DRAIN 1.0
% IUT Institute of Environmental Engineering

cd01path='C:\Program Files\CityDrain01';
cd01path_full=genpath(cd01path);
k=strcmp(cd01path_full,'');
disp('Matlab-path for CITY DRAIN 1.0:');

if k==1
     disp('HAS NOT BEEN SET !!');
     disp('Please check in startup.m if path is set correctly.');
     disp(' ');disp(' ');

else
     disp(cd01path);
     path(path,cd01path_full);
     disp(' ');disp(' ');
end

clear('cd01path');clear('cd01path_full');clear('k');
```

2 THE CITY DRAIN LIBRARY

To open the City Drain block library type

```
> citydrain
```

in the Matlab command window. Alternative, the Library can be opened via *"File/Open…"* :

```
C:\Programs\CityDrain01\CD1_CityDrain_Library.mdl
```

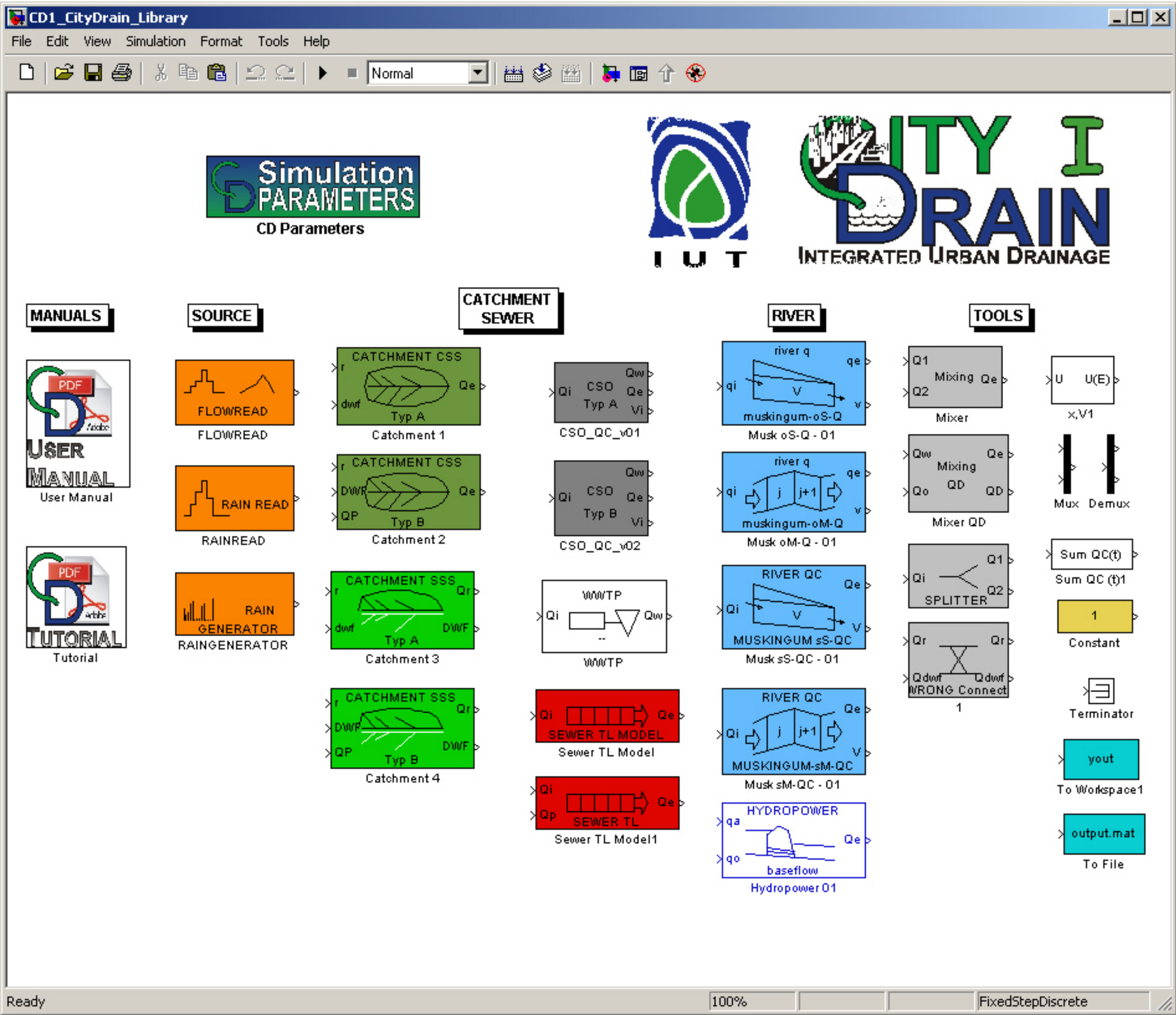


Fig. 1. City Drain 1.0 Block Library (*CD1_CityDrain_Library.mdl*)

The library contains blocks in 5 sections. Core block required for every simulation is the "CD Parameters" blocks organizing global setting for each simulation.

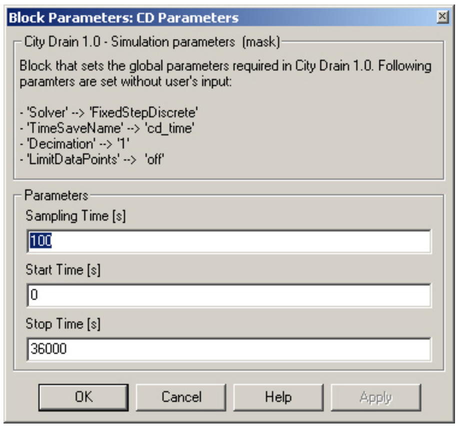
This manual as well as the User Manual may be opened via double click on the "Manual Blocks". The remaining blocks represent different parts of the urban drainage system and are described in detail in the User Manual. Therein data requested and provided as output by each block is shown as well as the models in behind. How to create a new scenario, perform simulations and cope with simulation results is shown in this manual.

3 SIMULATION PARAMETERS AND UNIT CONVENTIONS

CITY DRAIN and the library blocks implemented are designed to work within a discrete time scheme. Constant and discrete time steps are used within a simulation where simulation time and size of time steps are to be chosen by the used.

Core element of every CITY DRAIN simulation is the block **"CD - Simulation Parameters"**

CD Parameters



This block ensures that simulation parameters in the Matlab/Simulink © are set correctly. User input is required for the

- sampling time Δt,
- start time t_0 and
- stop time t_E.

of the simulation. The sampling time defined is utilized within all CITY DRAIN blocks provided, thus is being globally used. Hidden settings (without required user input) are made for

- 'Solver' ....'FixedStepDiscrete'
- 'TimeSaveName'........'cd_time'
- 'Decimation' ....'1'
- 'LimitDataPoints' ....'off'

THE BLOCK "CD – SIMULATION PARAMETERS" IS TO BE INCLUDED WITHIN EACH SIMULATION TO ENSURE CORRECT SETTING OF VARIABLES.

Convention regarding units in City Drain are as followed:

Q [m³/s]....... Flow [cubic meter per second]
V [m] .... Volume [cubic meter per second]
L [m] .... Length [meters]
t, Δt [s] .... Time [seconds]
C [g/m³] ...... Concentrations [gram per cubic meter]
M [g] .... Mass [grams]

4 SIMULATION OF AND EXAMPLE SCENARIO

4.1 Creating a scenario from the scratch

Fig. 2 shows the urban catchment(s) to be simulated. Thereby three sewer catchments in series, where CSO structures are located at the outlet of each of the catchments discharging in the river nearby. The simulation aims to quantify the resulting hydraulic and pollutant load associated from each of the CSO structures.

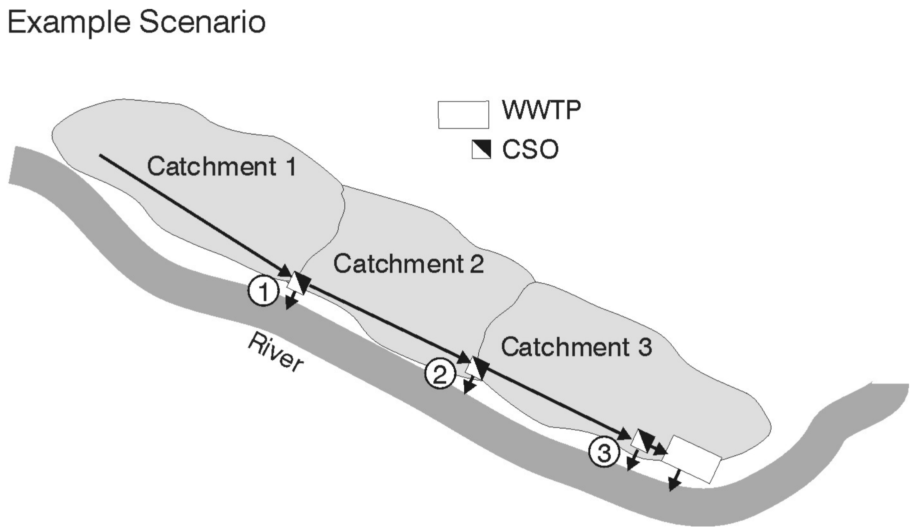


Fig. 2: Example scenario used in the tutorial.

The river itself is not simulated in this example, but could be included with no problem. For the simulation a ten year rain series (*Input_ixx_1y_example.ixx*) is used. Data on the Catchments and CSO structures can be found in Tab. 1 whereas information on pollutant concentrations applied in the catchment blocks can be found in Tab. 2 .

Tab. 1: Input data for Catchments and CSO structures

		# 1	**# 2**	**# 3**	**[...]**	
	Δt	300	300	300	[s]	Time step in simulation
Catchment	q_{dwf}	0,12	0,12	0,12	[m³/s]	Dry weather flow rate
	A_{RED}	200	200	200	[ha]	Reduced runoff area
	hi	1	1	1	[mm]	Inital loss
	hp	2	2	2	[mm/day]	Permanent loss
	n	5	5	5	[-]	Numb. of Δt
CSO	V_{CSO}	3000	3775	4870	[m³]	CSO storage volume
	q_E	0,52	1,04	1,56	[m³/s]	Maximum effluent flow

Tab. 2: Pollutant loads in all catchments, removal efficiencies applied to the WWTP

	COD [mg/l]	N_{TOT} [mg/l]	Cu [μg/l]
Stormwater	5,70	0,65	3,00
Dry Weather Flow	44,80	13,89	18,00
Removal Efficiency (WWTP)	80%	90%	90%

Starting a new modelling scenario from scratch is done by first opening the City Drain Library by typing >citydrain< in the command window. From the a blank modelling scenario is created with the button "New model (Ctrl+N)" or the equivalent option in the pull down menu (File>New>Model). This model can be stored at any desired location. For this example the model is saved to

D:\Daten\CDwork\Tutorial_Example.mdl

As said before, every scenario/model from City Drain requires the block "CD Simulation Parameters". This block as well as other is moved from the CITY DRAIN Library to the model by drag and drop. Alternative blocks can be copy using the clipboard function (Ctrl-C / Ctrl-D).

The simulation example planned shall be run with discrete time steps of 5 minutes. Therefore the block mask is opened by double clicking on the block.

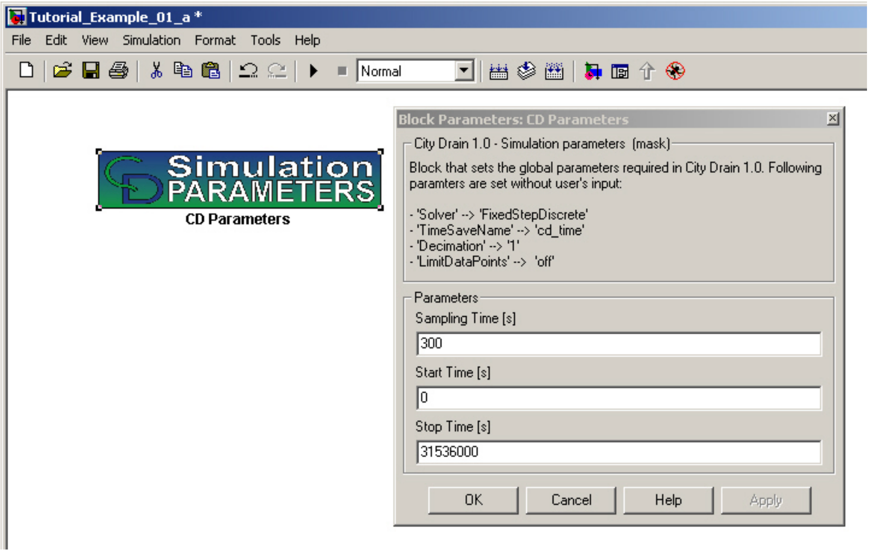


Fig. 3: Simulation parameters in the example

The first entry being the simulation time steps is to set to 300 [sec] according to City Drain convention to perform simulations using seconds as time unit. Start and End time are as well in seconds. Having a start time zero, the end time is 31 536 000 seconds (one year).

Rain data is read using the block "Rain Read". The file 'Input_ixx_1y_example.ixx' is located in the same directory as the model file is (*D:\Daten\CDwork*). Alternative, the file may be placed in any subdirectory as long the path is named in the block mask (e.g. *'Raindata\Input_ixx_1y_example.ixx'*)

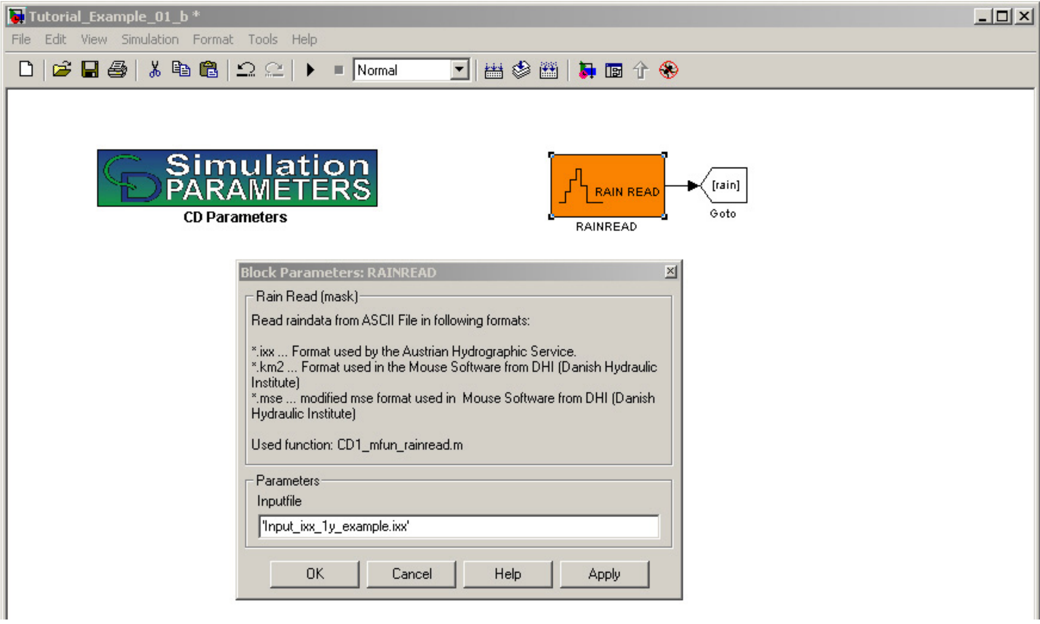


Fig. 4: Definition of Rain data used

The output of the block "Rainread" is to be linked to catchment blocks. In the example this link is not established directly, but by using "Goto" and "From" blocks from Simulink. Main advantage is to minimize the number of lines on the screen, especially when using the rain data multiple as input for different catchments.

The most upstream catchment and its CSO are included in the model as the next step. For the catchment 1, being a combined sewer catchment, the CSS Type A may be used.

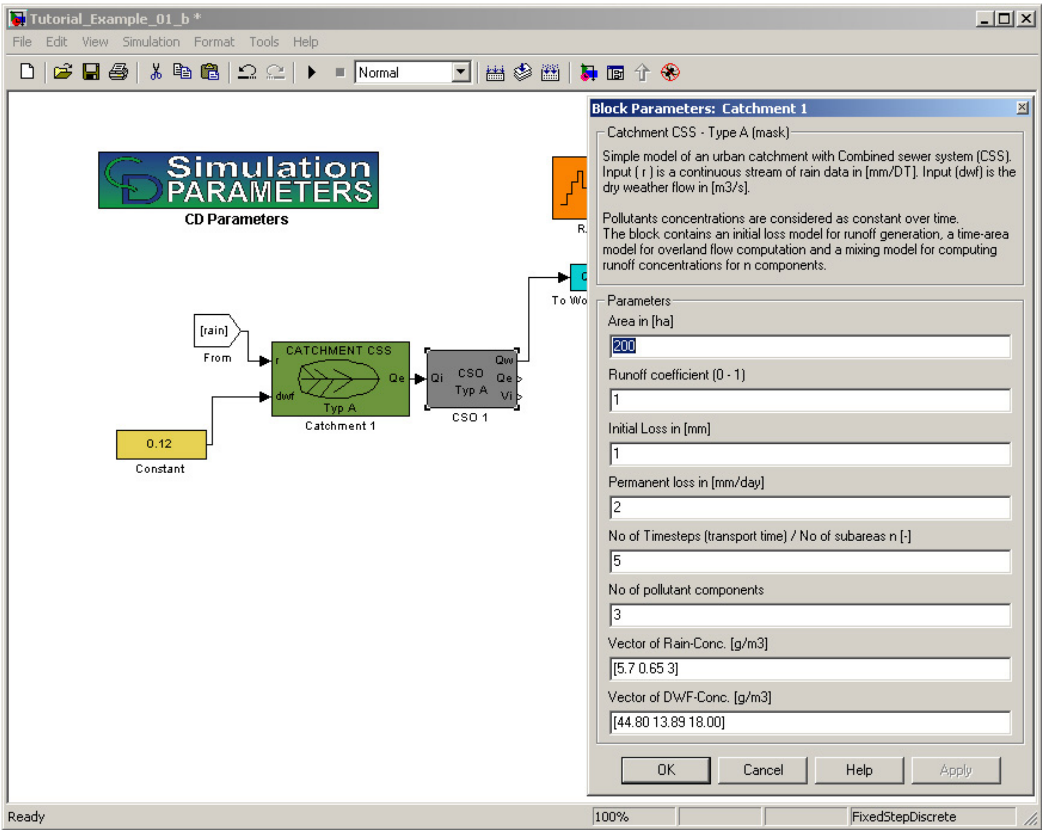


Fig. 5: Example Model – Including catchment and CSO

Dry weather flow is defined via the dynamic input port of the block, still being in that case defined as constant value (0.12 m³/s). Rain input is provided via the "From" block being linked to the Rainread - "Goto" block. In the block mask the area of the catchment, runoff coefficient, losses and the flow time (in terms of time steps) are defined. Further the number of pollutants carried and the concentration levels for rain and dry weather flow are defined here. All relevant data for this example can be found in Tab. 1 and Tab. 2. Similar to the catchment, the relevant data for the CSO block are inserted in the blocks mask.

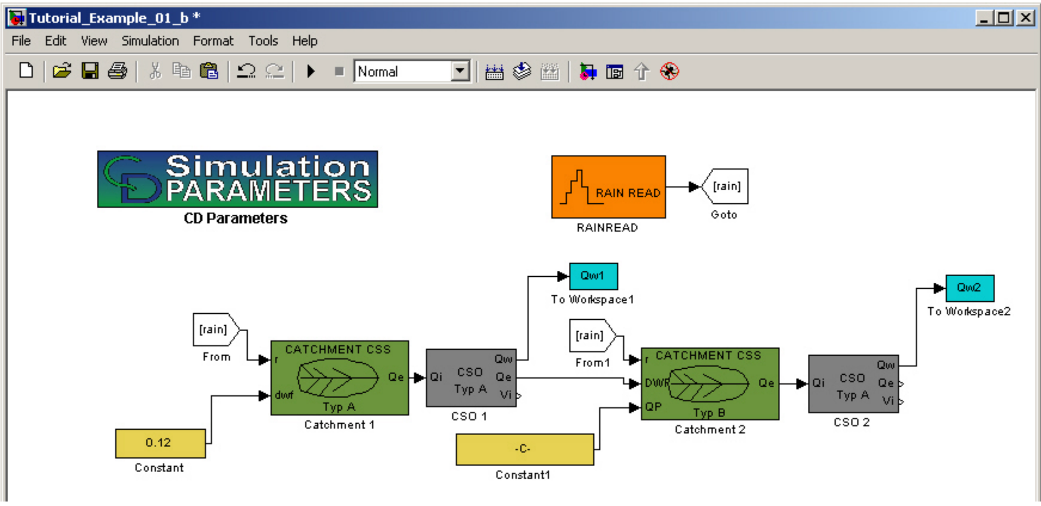


Fig. 6: Example Model – Including Catchment 2 and CSO 2

For the next catchment downstream, the catchment CSS-Type A can not be used. In order to feed flow from upstream into the block, the dynamic input port needs accept flow and concentrations associated. Therefore block CSS-Type B is used for Catchment 2. Flow and concentrations from upstream are fed to the block via port "DWF". Port "QP" is used for defining flows and concentrations generated in the catchment itself. Thus, in contrast to blocks of CSS-Type A, concentrations are not defined in the blocks mask anymore.

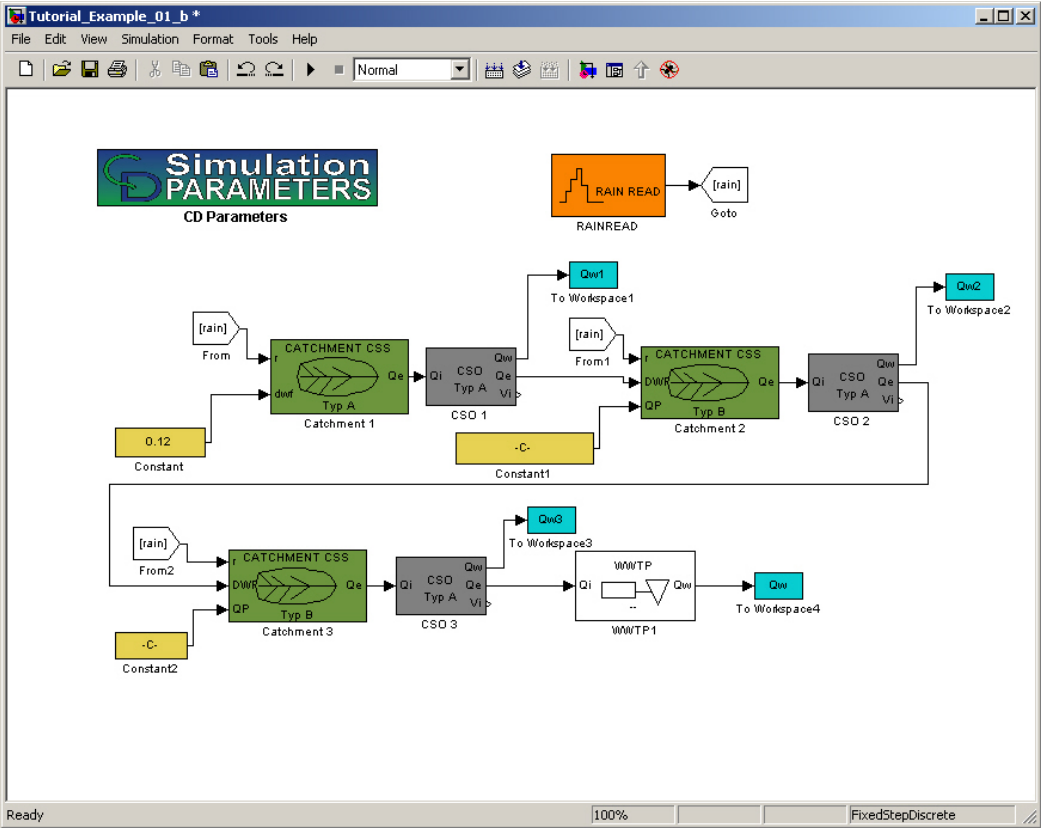


Fig. 7: Example Model – Final model generated

For Catchment 3 a block CSS-Type B is used, connected to a downstream CSO structure. Flow from the CSO structure is routed to a WWTP block.

4.2 Simulation of the scenario

The output generated at overflow ports (Qw) at the CSO's and the WWTP are routed to "To Worksspace " blocks. Thus, data generated during the simulation is stored in the corresponding variables at the Matlab Workspace.

The simulation is started via the PLAY (Start-simulation) -Button of the Simulink window. This is feasible when the size of the scenario and thus the simulation time is small. For cases where larger data quantities are treated, the simulation may be started in batch mode via the a Matlab Command Line.

> sim('*Tutorial_Example');*

Parameter is the model file name: *Tutorial_Example.mdl,* excluding the extention. Output is generated at the workspace for each variable (see Fig. 8). The time is stored in "cd_time".

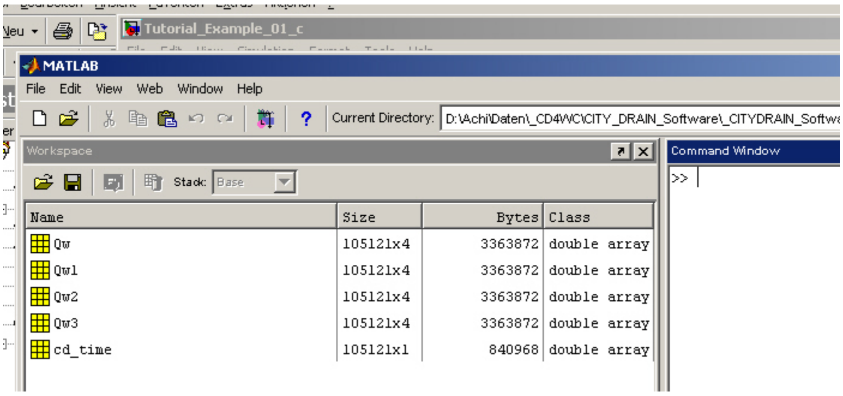


Fig. 8: Workspace output of simulation.

With the so generated output, standard Matlab functions may be used for post processing and visualization. In the first column of the variables, the flow q [m³/s] is stored. Remaining columns contain the concentrations (in this case columns 2,3 and 4). The order of pollutant concentrations stored is as defined earlier in blocks in the simulation model. Thus the resulting variables are comprised of [q COD N_{TOT} Cu].

E.g.: Plotting of the overflow generated at CSO 1, is done by

> plot(cd_time,Qw1(:,1));