Temperature estimation in sewer pipes (Riotherm) model

User manual

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August 2015

Version 1.0

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Disclaimer

The files package, data and information (applies also for the information provided in this manual) was developed in partnership with KWR Water Research Institute, Delft University of Technology, Deltares and Waternet. However, everything is provided “as-is”. The software is no warrantied and none of the creators will respond for any damage to the software (applies also for third party software) or software resulting from its use.

Introduction

The files package was designed as an add-on for the urban drainage software Sobek to calculate longitudinal temperature of water and longitudinal, radial and tangential temperature of circular pipes and surrounding soil. For a descriptive concept of the temperature model, the reader can access to Elias Maxil (2015).

Since the hydraulics in the pipe are calculated with Sobek, and the basic setup (including the installation of Sobek) are managed within this software, the reader can refer to the Sobek manual (Deltares, 2013, 2014) for detailed information on the hydraulic concepts, and more features of the software at www.deltares.nl (2015) or at the manual provided in the Sobek suite.

Requirements

The hardware and software requirements to run the temperature add-on depend on the requirements to run Sobek.

The minimum specifications are:

- 1 GHz Intel Core processor or equivalent
- 2 GB internal memory
- 10 GB free hard disk space
- Screen resolution 1024x768
- Microsoft .NET Framework 4.0

Although faster processor clocks are recommended due to the amount of calculations added to the hydraulic calculations when the temperature model is included.

The add-on has been tested in Sobek Advanced Version 2.12.003 and Sobek Advanced Version 2.13.000.26. The Sobek suite has been ran in Microsoft Windows 7 and 10.

Content of provided files

The files accompanying this manual are:

- Temperature model package (Riotherm) version 3.2
- Folder “OpManual.lit” which contains the example of the model in Sobek (Below)
- Folder “Weather(FixedFolder)” which contains different files needed in Sobek to run the example.

Installation instructions

Preliminary instructions

The temperature model (Riotherm) will only work once Sobek is installed. The add on will run when the water quality module (1DWAQ) is active. For licensing and activation of the water quality module, please refer to the Sobek suite at www.deltares.nl.

Temperature add-on installation

Once the 1DWAQ module is activated, the add on is installed in the Sobek directory. A set of batch files are included in the folder Riotherm:

1. Backup commands of files to be replaced
2. Batch file with main origin _ destiny directories
   2.1. Commands with files to be added/replaced

Before using the batch files, check whether the destiny directory is correct, in the batch files provided, the Sobek directory is written "D:\Sobek213" or "D:\Sobek212" these directories will change according to the drive and Sobek version installed in each computer.

Building a new schematic model from scratch

New simulation

Once a project has been created in Sobek, the case management window will appear.

To start from scratch please select:

- Case → New

The case *Default* will be created nd the blocks **Import Network, Settings** and **Meteorological Data** will change their color to yellow. Click in the block **Import Network** and a window with options will appear, select:

- Start from scratch

Meteorological data

The block **Import Network** will change its color to green. In **Meteorological Data** the dates of the simulation, have to be defined as well as the precipitation, evaporation and wind. Please refer to the Sobek manual for more information about the input needed in this block.

Water quality settings

In **Settings**, the modules *1DFLOW (Rural), 1DFLOW (Urban), RR* and *1DWAQ* have to be activated. To select the proper options in the flow and RR[1] modules according to the Sobek manual.

In order to select and use the temperature module (**Riotherm**), edit the options of the 1DWAQ module. For the edition of the *1DWAQ* module (clicking the "Edit …" option on the right of the module's name) a new window will appear.

[1] RR: Rainfall Runoff

At the tab <u>Time settings</u>, the time step of the water quality simulation, must be equal to the flow and RR modules.

In the tab <u>WQ processes</u> (Figure 1), in “use predefined process”, select “Riotherm”.

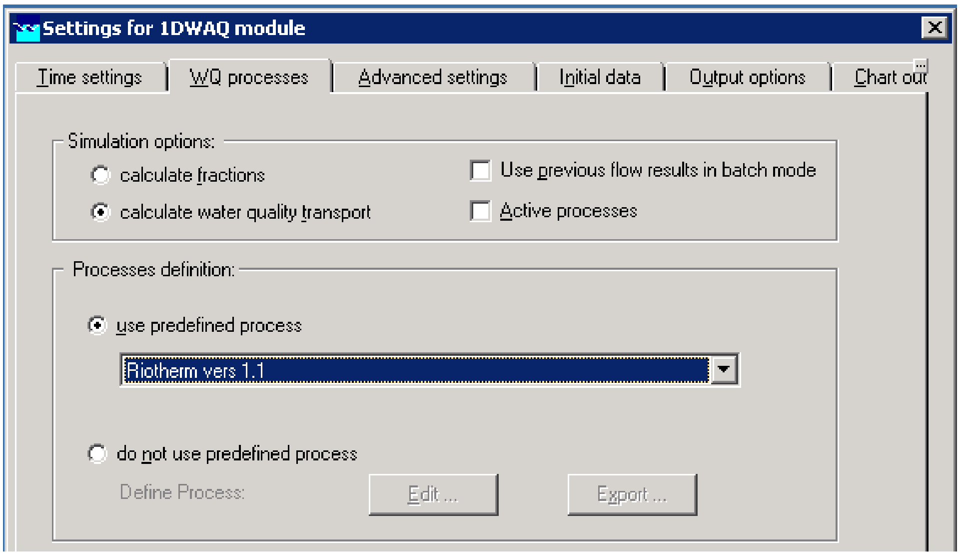

Figure 1: 1DWAQ options

In order to define the process coefficients (Thermal parameters, geometric characteristic of the pipes, numeric for the solution of the model) select the *Edit Process Coefficients* option. There are two coefficient groups available: Thickness factors of pipe and soil and process coefficients.

In the first group, the thickness factors correspond to the factors K_P and K_S explained in Chapter 4 at {Elias Maxil, 2015 #1360}. The process parameters of the model are stated in the second group (Figure 2). An equivalence between the name of each parameter in Sobek and the model explained in {Elias Maxil, 2015 #1360}, is shown at Table 1.

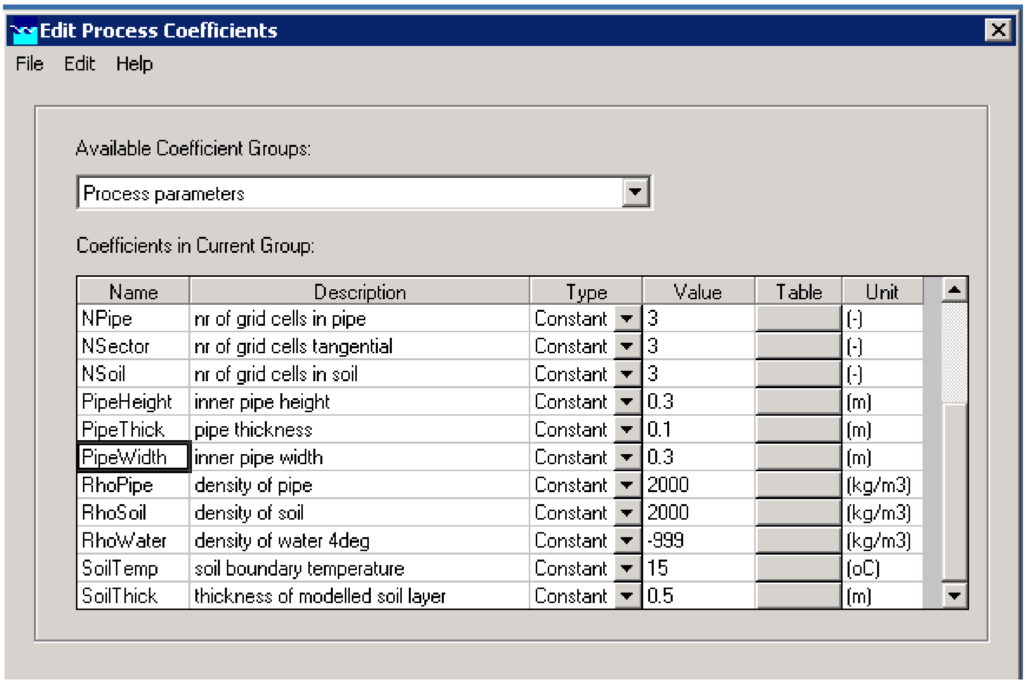

Figure 2

Table 1: Equivalence between symbols at {Elias Maxil, 2015 #1360} and Sobek Riotherm add-on.

Parameter	Symbol	Equivalent in Riotherm
Factor thickness in pipe	K_P	mfPipeSeg
Factor thickness in soil	K_S	mfSoilSeg
Number of grid layers in pipe	n_P	NPipe
Number of grid layers in soil	n_S	NSoil
Number of grid sectors in tangential direction (half pipe)	m	NSector
Specific heat capacity pipe	cp_P	CPPipe
Thermal conductivity pipe	λ_P	LambPipe
Pipe internal diameter	D	PipeHeight, PipeWidth
Pipe thickness	δ_P	Pipe Thick
Density of pipe	ρ_P	RhoPipe
Specific heat capacity water	cp_W	CP
Soil boundary temperature	$T_{S,inf}$	SoilTemp
Thickness of modelled soil layer	δ_P	SoilThick
Density of soil	ρ_S	RhoSoil
Water density	ρ_W	RhoWater
Specific heat capacity soil	cp_s	CPSoil
Thermal conductivity soil	λ_S	LambSoil

Please, always use *File* → *Save* → *Exit* before closing the *Edit Process Coefficients* window or the parameters will not change from the default values. At the Advanced settings tab, the working integrations options so far are the numerical scheme 10 and 17. In the Initial data tab, select “use global initial values” and “edit”. A window will appear. The window shows the initial conditions of the pipe and soil for the simulation. The ID “Mod Temp”, “Check” and “Check2” represent the initial temperature of the water. The ID “RioTemp1_1” to “RioTemp9_8” represent the value of each perpendicular segment of pipe and soil (Figure 3).

The tab Output options has a feature in “History and balance output locations” to retrieve the temperature results in two ways: For the whole longitudinal segments of the pipe (*write output for all segments*) or for certain parts of it (*write for monitoring stations only*) defined by the user. More features of the **Settings** tabs are explained in the Sobek manual.

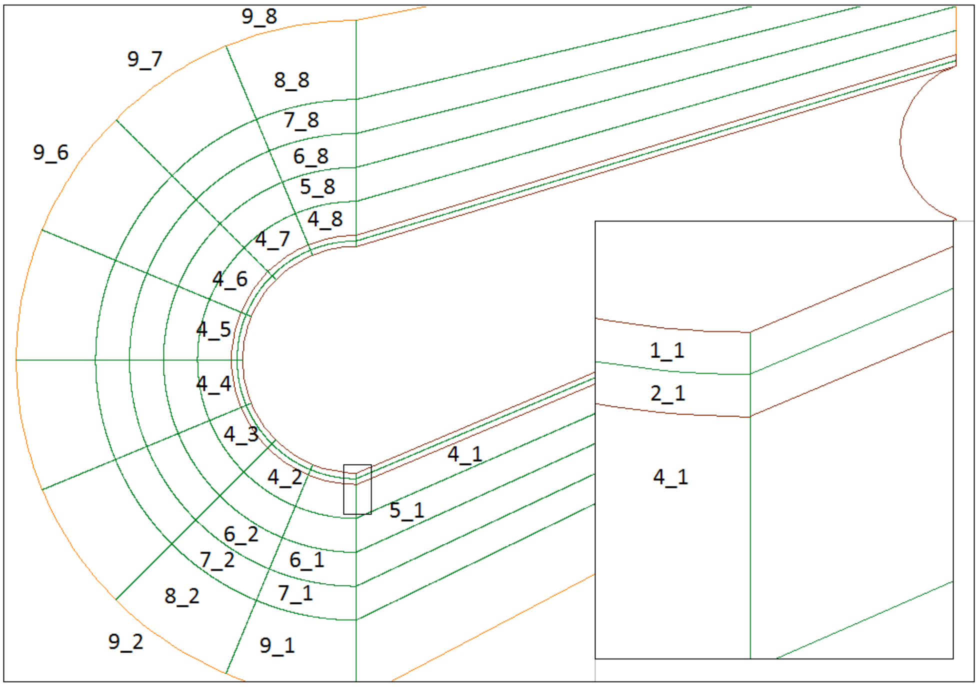

Figure 3: Nomenclature of radial and tangential segments of pipe and soil.

Setup of pipe and surface water type for the temperature model

To determine which pipes of a network will be modelled with the temperature add-on, it is necessary to declare it before building the network.

1. At the case management window, the **Schematisation** block when it is double clicked, a window with option appears.
2. Press the option *"Edit user defined objects"*.
3. At the window *"Edir User Defined Objects…"*, add an Active surface water type (in the *"Surface Water Types"* area) calling it with any name. At the example provided, it is called Riotherm.
4. At the *"Branch Objects"* area, add an *"Active branch objects"*. At the example provided, it is called Riotherm again (Figure 4).
5. At the option *"Selected parent type"*, Select Flow – Channel and Riotherm as "*Selected surface water type*" (Figure 4).

Creation of schematic model in Sobek

The creation of a network from is made based on the instructions published in the Sobek manual and information found on the help files in Sobek.

Instructions:

1. Press *"Edit model"* in the **Schematisation** options. The network editor (Netter) will open.

   Under Netter, press the icon *Edit Model*  and add two Flow – Boundary nodes (Figure 5).
2. Connect the nodes with a temperature pipe (Figure 6).

3. Add Cross sections nodes following the previous first step and adjust the properties of the pipe (diameter, upper and lower level, shepe, friction, location). **Important!:** the temperature model works only with circular pipes (Figure 7).

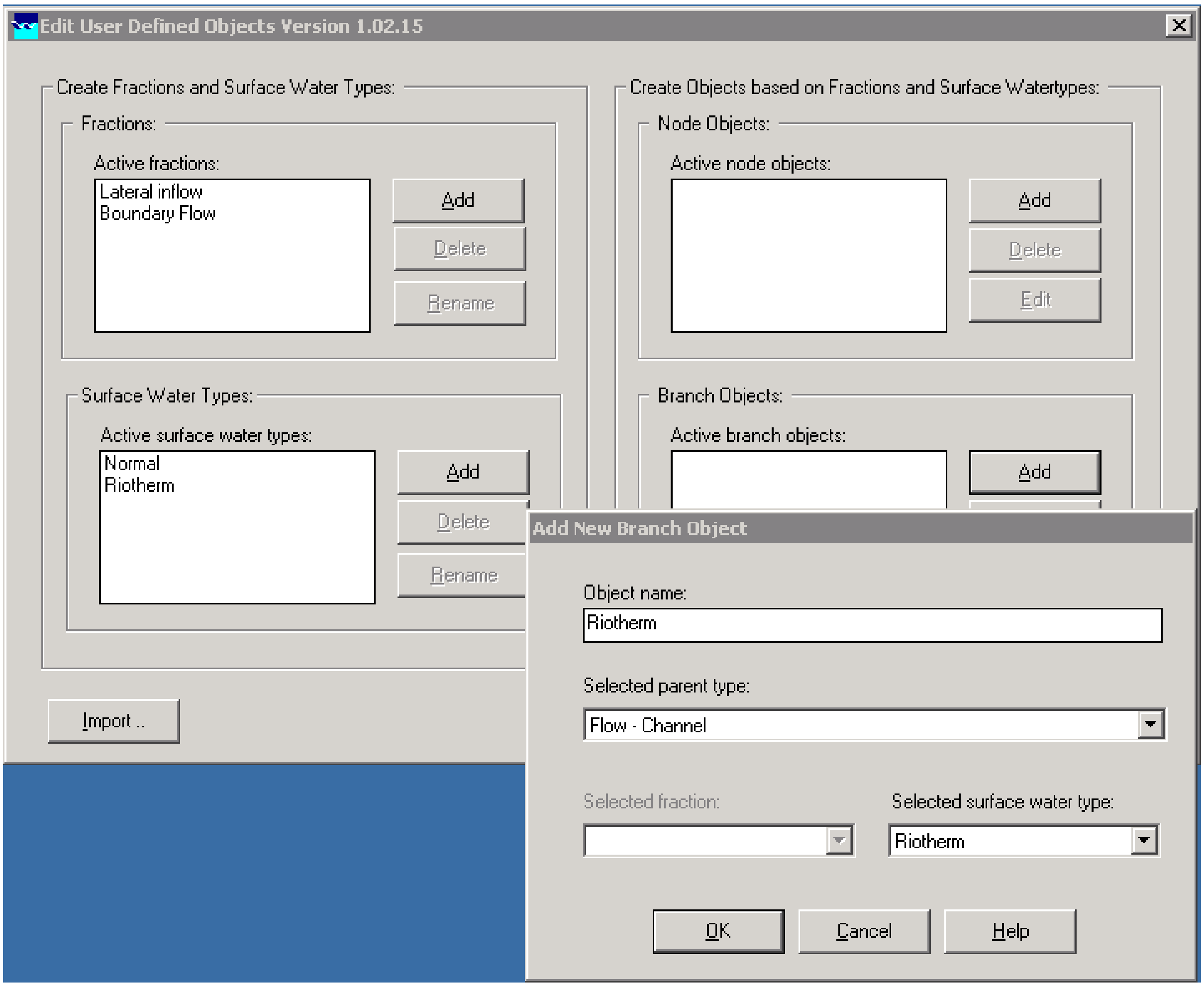

Figure 4. Setup of surface water type and pipe.

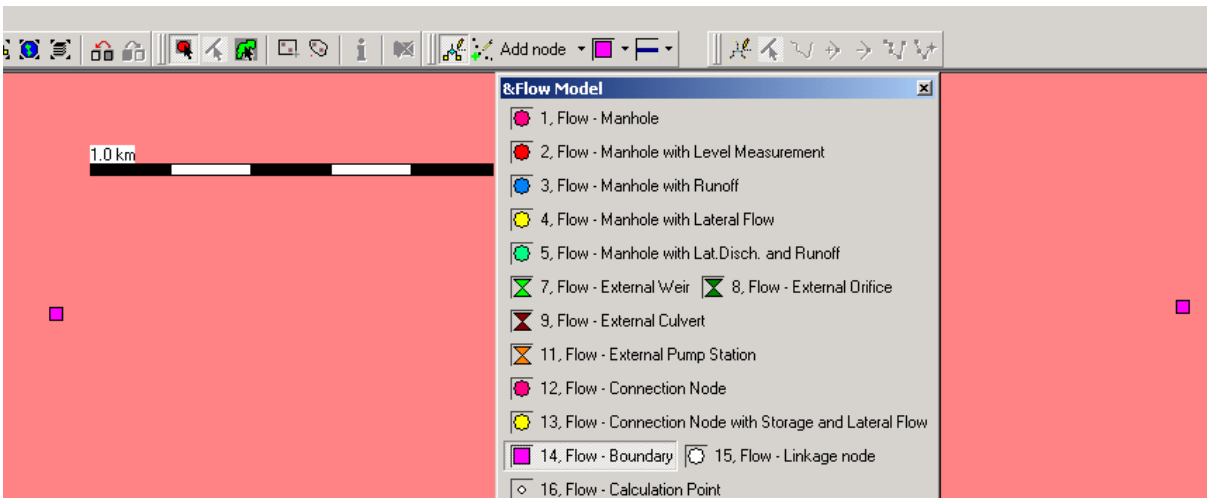

Figure 5

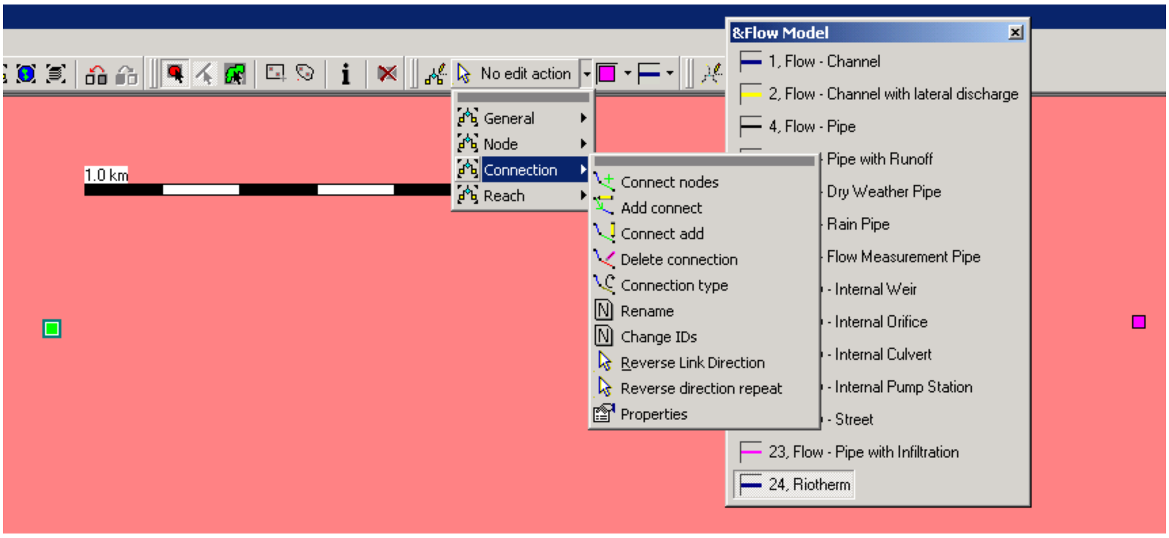

Figure 6

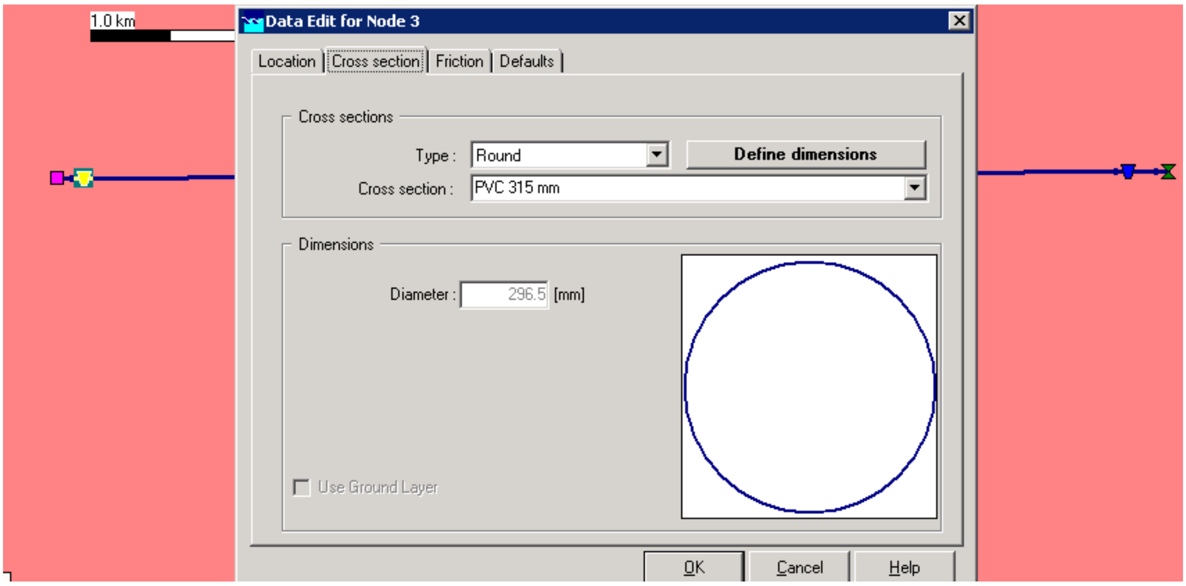

Figure 7

4. Select the *Edit Network* icon ≫ *Reach* ≫ *Calculation grid reach* to set the longitudinal discretization of the model (Figure 8).
5. Activate the temperature model (Water Quality segments) by selecting *Edit* ≫ *Delwaqsegments* ≫ *Auto* (and optionally, change the segments' atributes). The "Riotherm" pipes will be shadowed when the operation is successful.

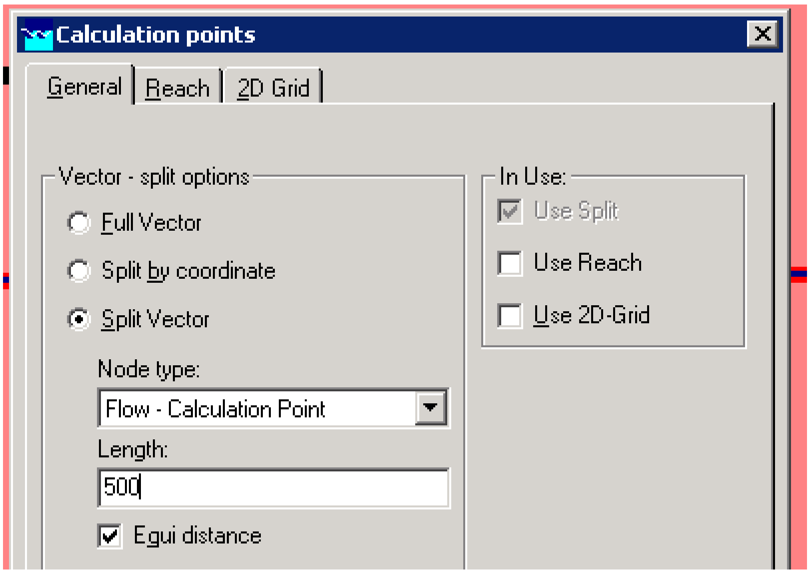

Figure 8

Data input

1. Select the upstream node, with the secondary mouse bottom select *Model data ≫ Flow Model* (New tabs will appear). The input table (for unsteady conditions) for incoming water to the network is shown by clicking to the options "*Value, Funtion of time ≫ Table…*".
2. The input table for the incoming water temperature is shown by going to the "Time dependent" option of the "Concentration" tab (Figure 9 and Figure 10).

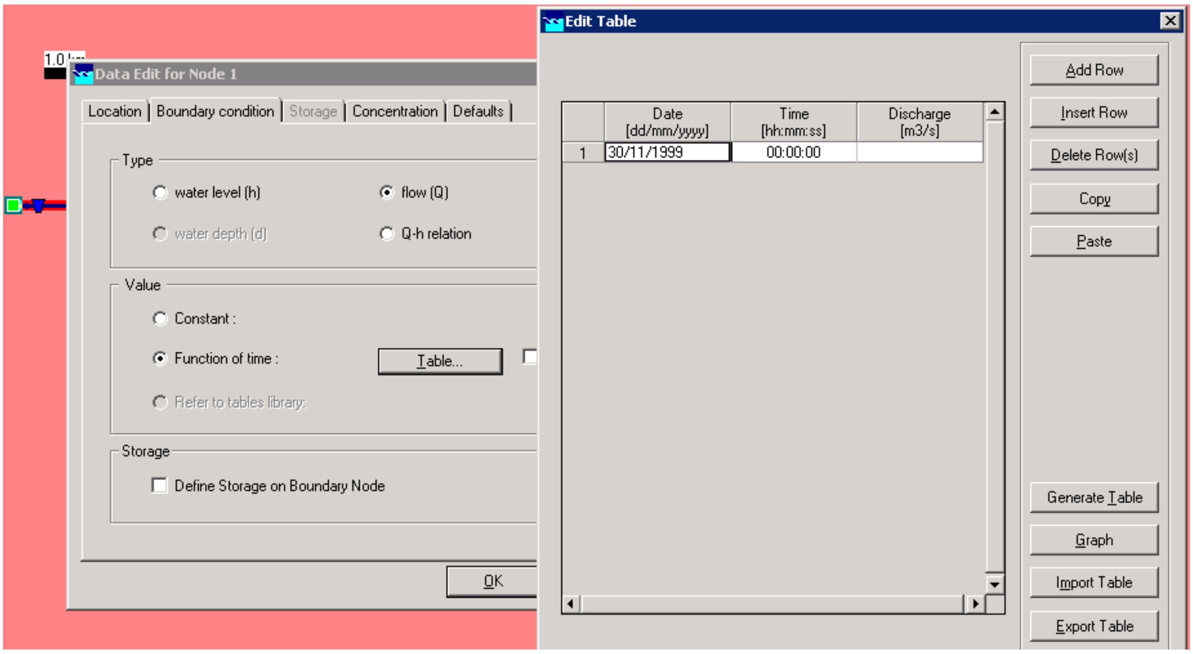

Figure 9

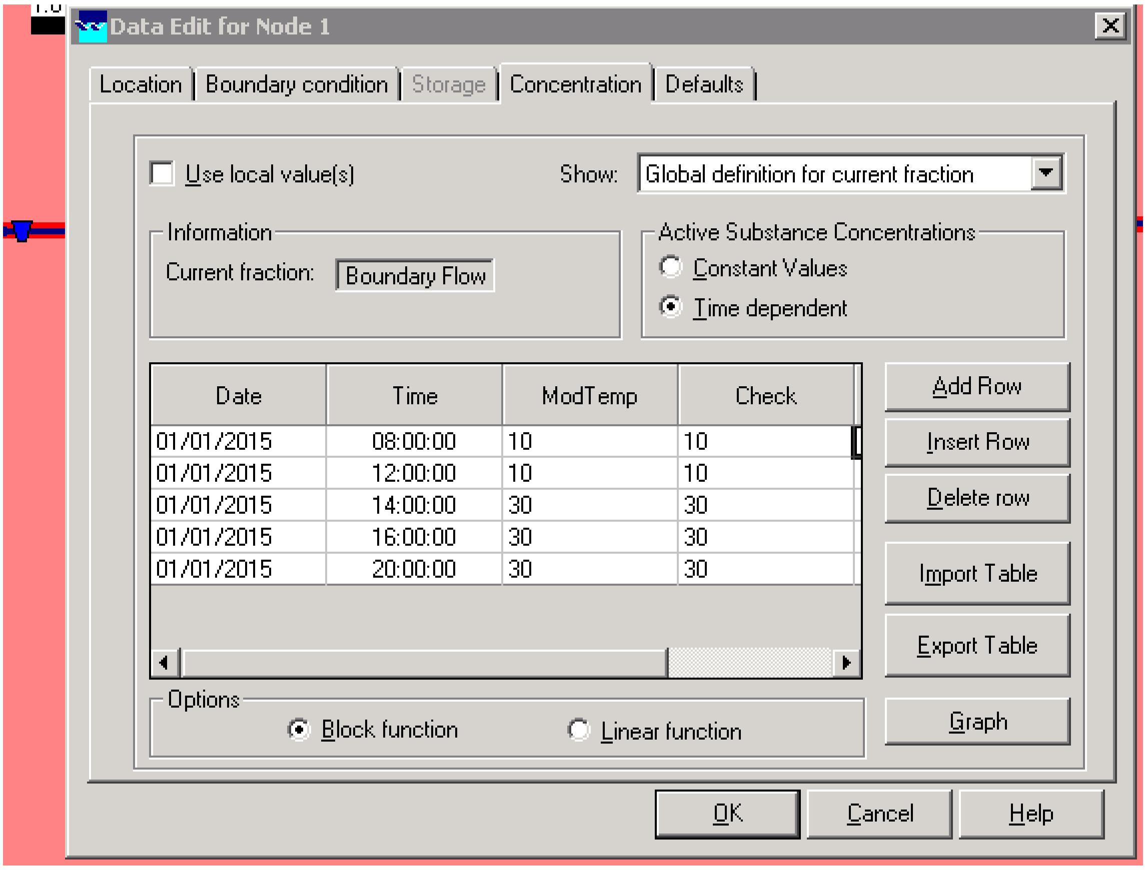

Figure 10

Simulation and results

When the option "*write output for all segments*" in the tab Output options of the **Settings** task block is chosen, the identification (ID) of the temperature segments is shown showing the "*Legend*" options and selecting *Delwaq ID* of the *Link* tab as in Figure 11.

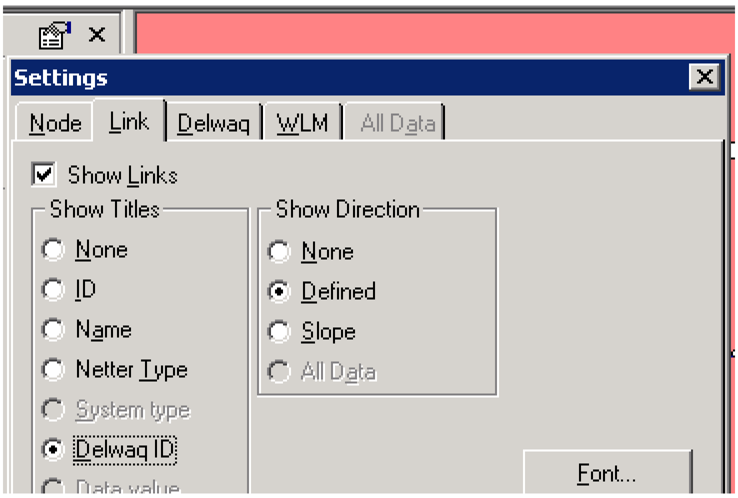

Figure 11

Close **Netter** and the **Schematisation** window to simulate the model. The model starts by clinking the **Simulation** task block.

Once the simulation has finished the results can be read according to the Sobek user manual. The temperature results are shown in the "*History Results of Water Quality*" of the "*Results in Charts*" task block.

References

Deltares, 2013. Sobek. User Manual, In: Sobek (Ed.). Deltares systems: Delft, Netherlands, p. 910.
Deltares, 2014. SOBEK 3, Technical Reference Manual, In: Deltares_Systems (Ed.), Sobek 3. Hydrodynamics. Deltares: Delft, Netherlands, p. 118.
Elias Maxil, J.A., 2015. Heat modeling of wastewater in sewer networks: Determination of thermal energy content from sewage with modeling tools, Water Management. Delft University of Technology: Delft, p. 180.