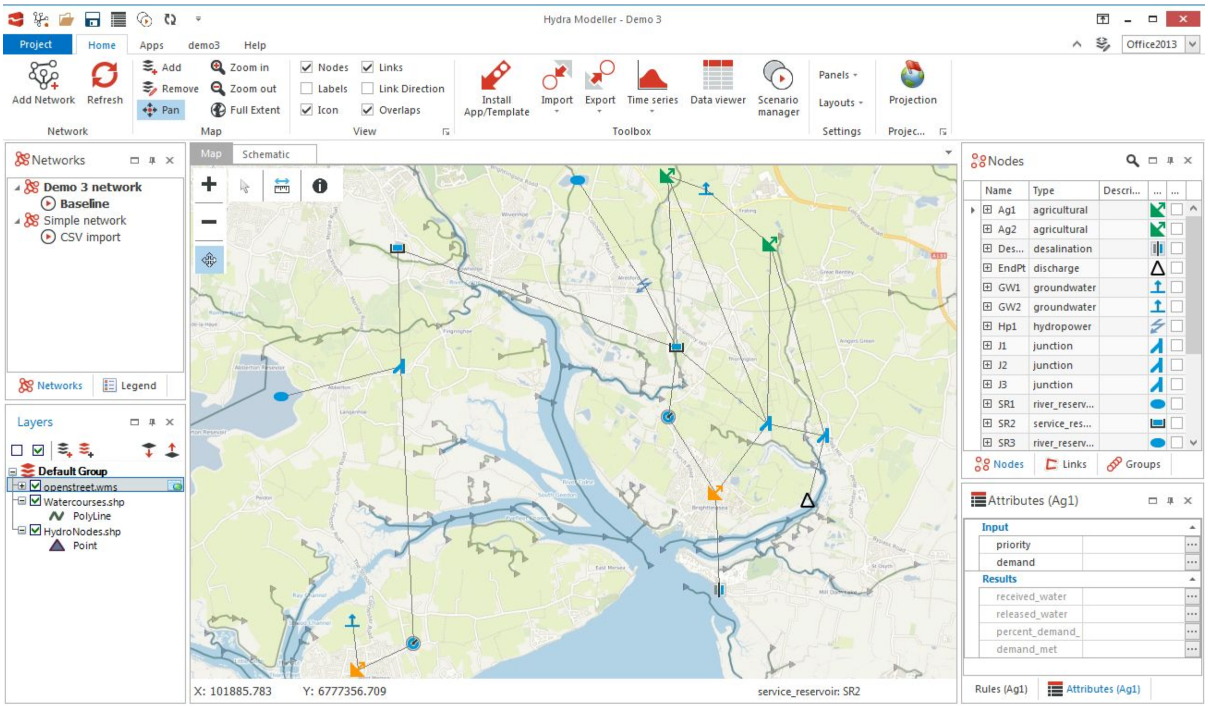
The Water Allocation Demo Model

Stephen Knox, University of Manchester, December 2015

The Water Allocation Model was developed by the research team of Prof. Julien Harou and is designed to distribute water from a variety of supplies (River reservoir with inflow, desalination with sea inflow and Groundwater with groundwater inflow) to three types of demands (urban, agricultural and discharge which can be considered an environmental demand in terms of minimum flow required to be delivered to a river). The water allocation model is written in Generic Algebraic Modelling System (GAMS)[1] and is a generic simple application to explore water resource planning issues and is designed for a university level tutorial.



In summary

Water is transferred along conduits (which could be either rivers of pipes which have maximum and minimum flows as well as a flow_multiplier value (0-1) to represent the potential for losses (e.g. leakage and evaporation). If the flow_multplier is less than one some water is lost. A priority value is assigned to each demand node (urban, agricultural and discharge) to represent the importance of water being provided to each demand. If all priorities equalled the demand for each node, then each demand node would be considered to have equal priority of delivery. When drought occurs, demand node(s) with the highest priority will face the least water shortage. There are water treatment works that affect the flow based on their min and max storage and their percent_loss (i.e. a percent_loss of 5%

[1] http://www.gams.com

means that 5% of the water is lost to process needs). A hydropower node is included to capture how much water could be available for power generation and a simple calculation is included to calculate revenue (dependent mostly on the net head at the site location and the flow of water. You can take a look at the model formulation in the allocation.gms file.

Water Allocation Model in Hydra

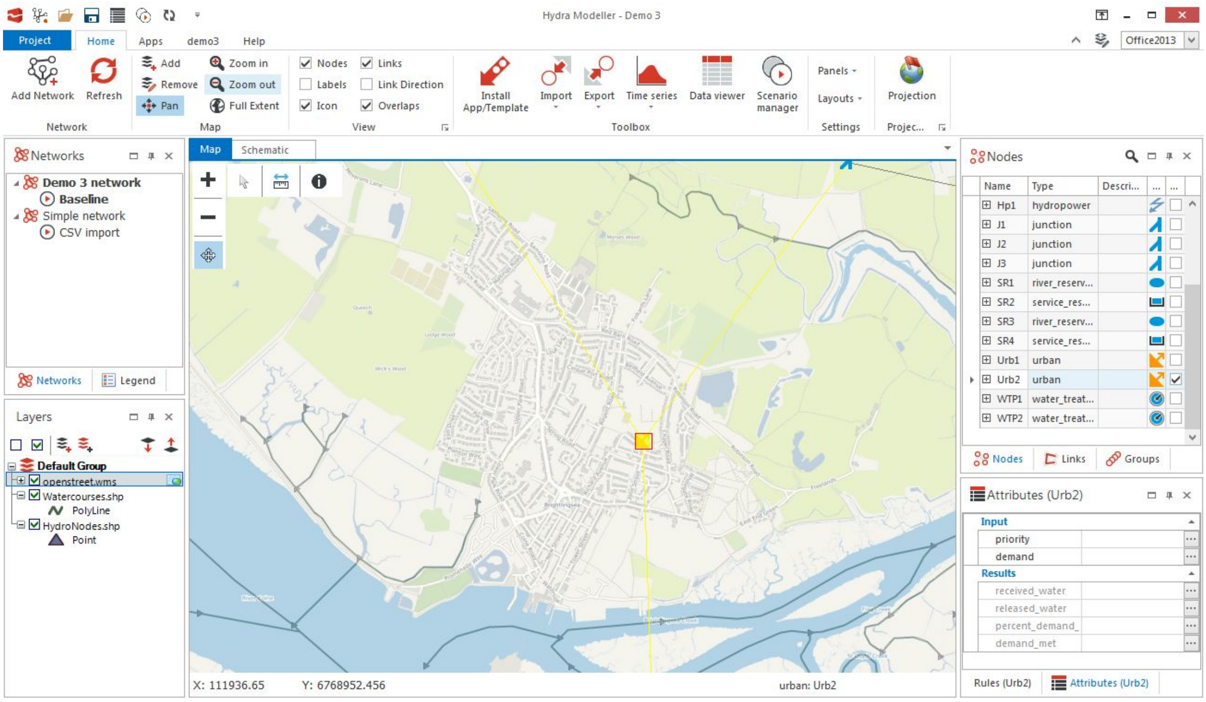
In order to explore the model with Hydra, a user must have the **latest version of GAMS** installed, must have the model itself and its data in CSV or Excel format (for importing into Hydra) and must have the Hydra GAMS App, which communicates the data within Hydra to GAMS and which loads results into Hydra.

For instructions on how to find the water allocation model on the Hydra App Store, see the ‘Getting Started’ document.

Inspecting the data

Having loaded the data, ensure the ‘Baseline’ scenario is active.

Notice how the orange node is located over a city, and when selected via the ‘arrow’ button on the interface, changes colour and is highlighted in the right-hand menu. Its attributes: priority and demand are available to view also, on the bottom -right.



- In turn, click on each supply node

- Click on the *inflow* attribute, followed by the ‘timeseries’ button (top menu) and the time series button for the inflow attribute in the attribute viewer.
- Do the same for each demand node, selecting *demand*.
- This will give you a comparison of inflow versus demand for each node.

This is a simple 9 month model with monthly time steps and the initial boundary conditions include an initial_storage for all of the supply sources. Your time series plot will look similar to the image below.

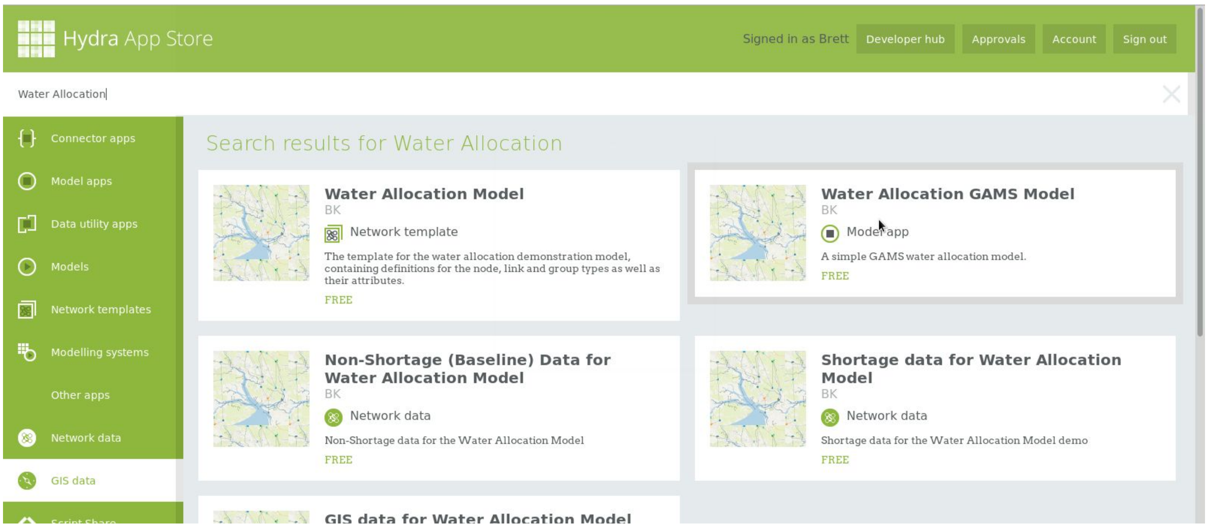
Finally, notice on the bottom of the ‘Attributes’ section for each node, there is a ‘Results’ section. Notice that these are inactive -- there is no result data available. This means the model has not been run. So let’s do that now.

Running the Model

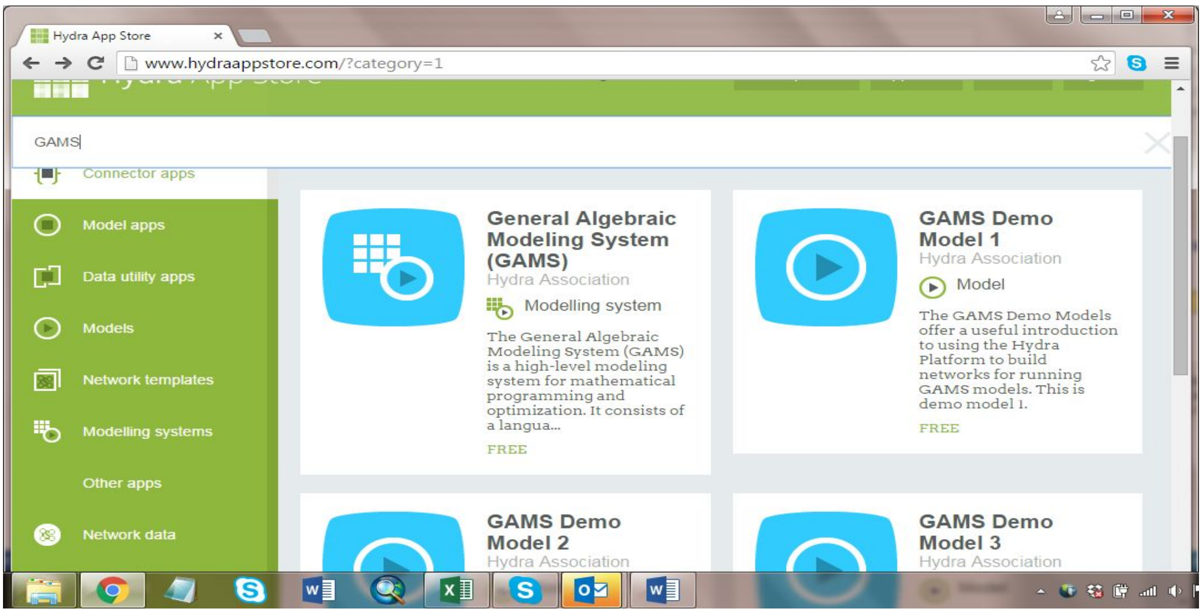
The purpose of this model is to allocate water based on priority such that if there is a shortage of water, those demands with lesser priority will receive a smaller percentage of their demand. Priorities are assigned to each demand node dictating which node must receive water first.

In order to run this model, you will need to:

- Go to the Hydra App Store to download the model and the GAMS software (USE THE 64-bit VERSION). Go to http://www.hydraappstore.com/, and gain access with:
- User: hydra
- Password: burderopSN40QD
- You don't need to sign in to download free Apps, only to submit reviews, become a developer and purchase commercial Apps. This site is still in demonstration mode, so prices are fictitious and the text is not finalised.
- In the search bar near the top, type in "Water Allocation". You will see a collection of Apps relate to the model, one of which is the model itself:



- Download the model.
- In the search bar near the top, type in 'GAMS'. You will see a collection of Apps relating to GAMS, the first of which is the modelling system itself. If you do not have GAMS already installed, click on the 'Generic Algebraic Modelling System' app, then download and install it. **Make sure you are installing the 64 bit version of GAMS and that its version is greater than 24!**



You are now ready to run the model.

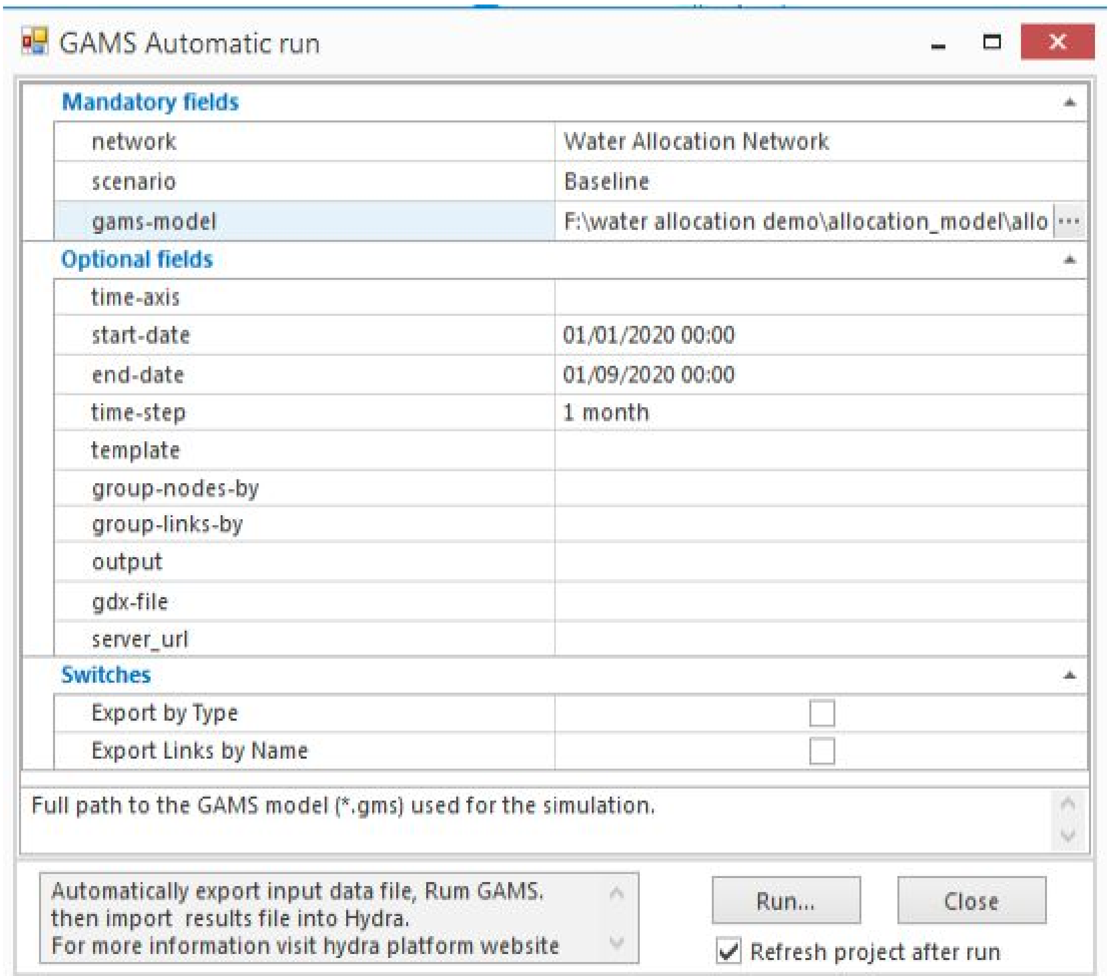
Time Steps

The GAMS app needs to be told what time-steps to run for, so it can retrieve the correct data from Hydra. This can be specified manually when running the app or, more easily, set as a property on the scenario so it's automatically filled in every time you run the model.

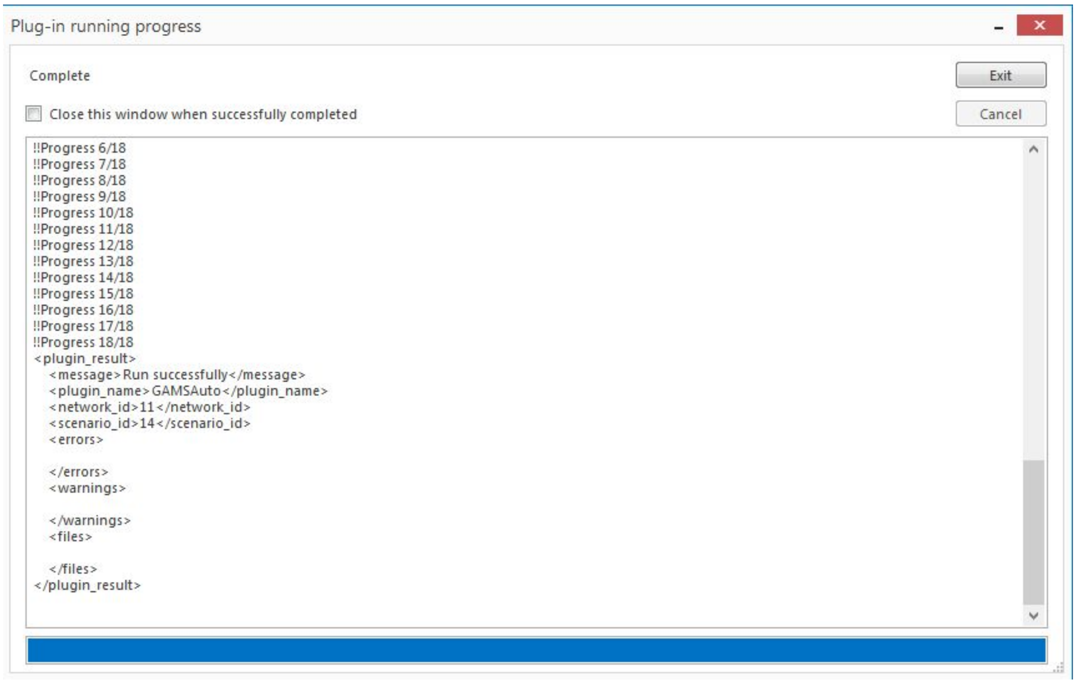
Before sending a set of scenario data to GAMS for a model run, right-click on the scenario, select properties and make sure the start time is January 1st 2020, end time to September 1st 2020 and the time step is “1 month”. GAMS models compatible with this app need the time-step to be manually specified. **The ‘1 month’ format is important and must follow this format, as it indicates to the app what the time-step for the model should be.**

- Now select the Apps tab and click on the GAMS Automatic run. The start time, end time and timestep should be pre-populated based on the scenario properties. All that's left to do is select the Network, Scenario and then locate the GAMS model you downloaded previously. The GAMS model is the allocation.gms file

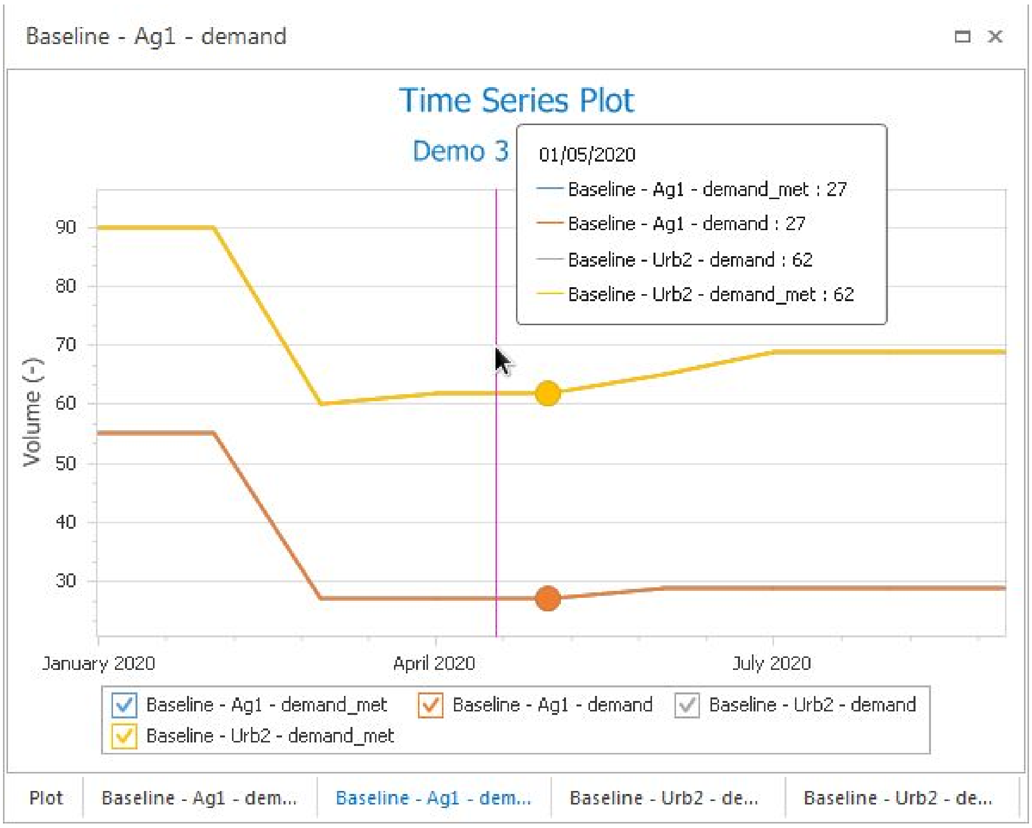
- Once the Mandatory fields and the scenario time information has been entered, Click on Run to run the model.



- Hydra Modeller will report on the progress of the model run.



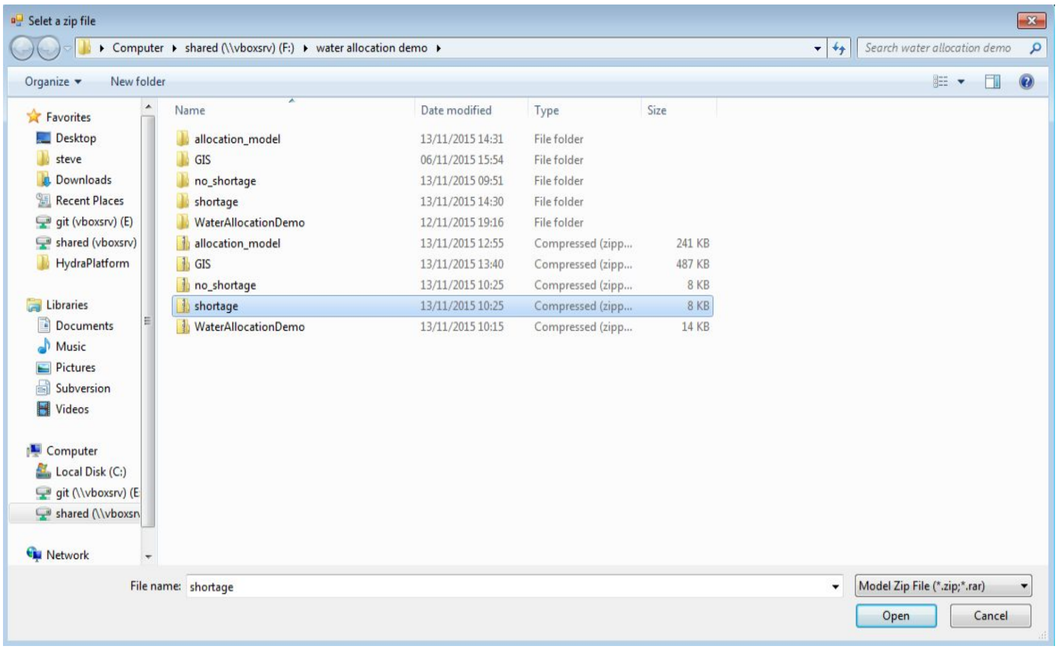
- After the model is complete and results have been returned from GAMS to Hydra, Click on the Ag1 and Urb 2 demand nodes and select demand_met and demand, followed by 'Time series -> general' on the top menu to see if there was enough water to satisfy all demands. Because this sample data set has enough water supply, all demands have been met. The demand and demand_met are equal for two separate demand nodes, demonstrating that for this scenario the demand has been met for these nodes:



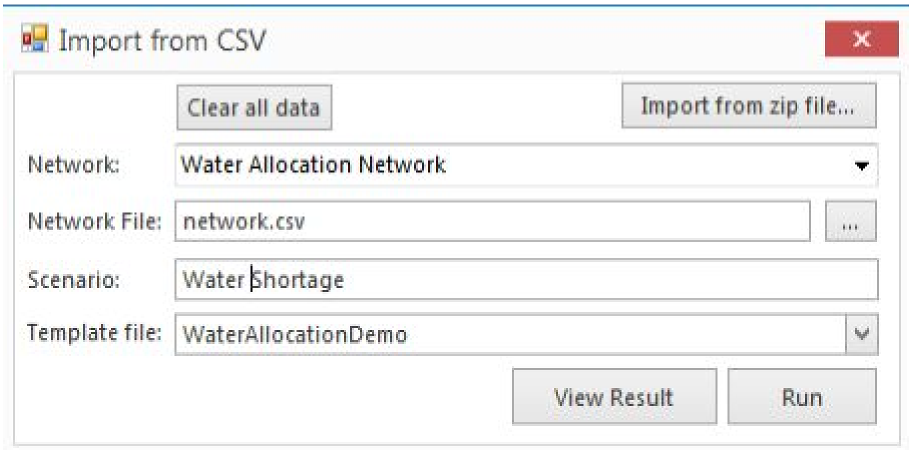
Run a variation of the scenario.

There are two approaches to creating a new scenario -- cloning an existing scenario or uploading different scenario data. This example explains the latter.

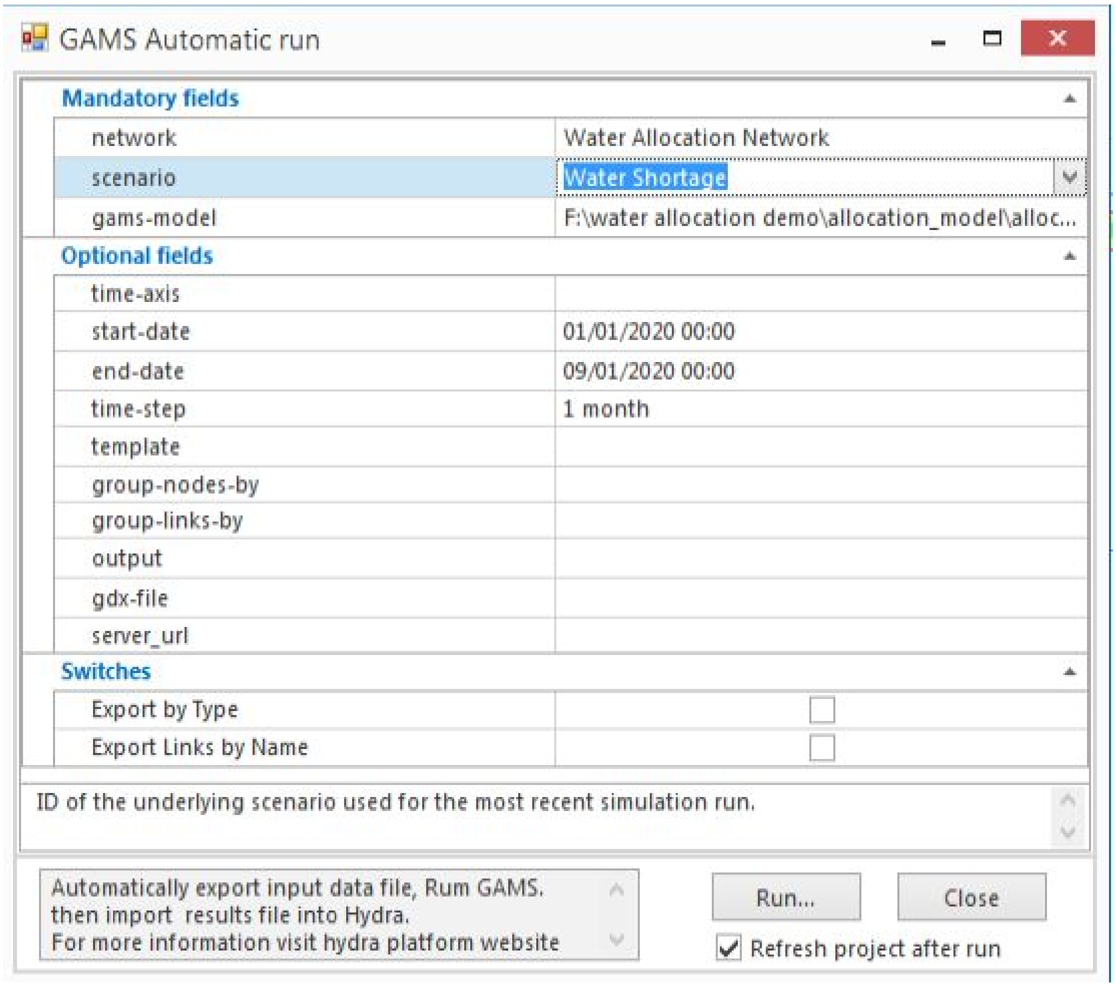
- First, search for and download the ‘Shortage data’ for the water allocation model on the hydra app store.
- Next, click on ‘Import -> From CSV’
- Click on ‘import from zip file’ and navigate to the new dataset:



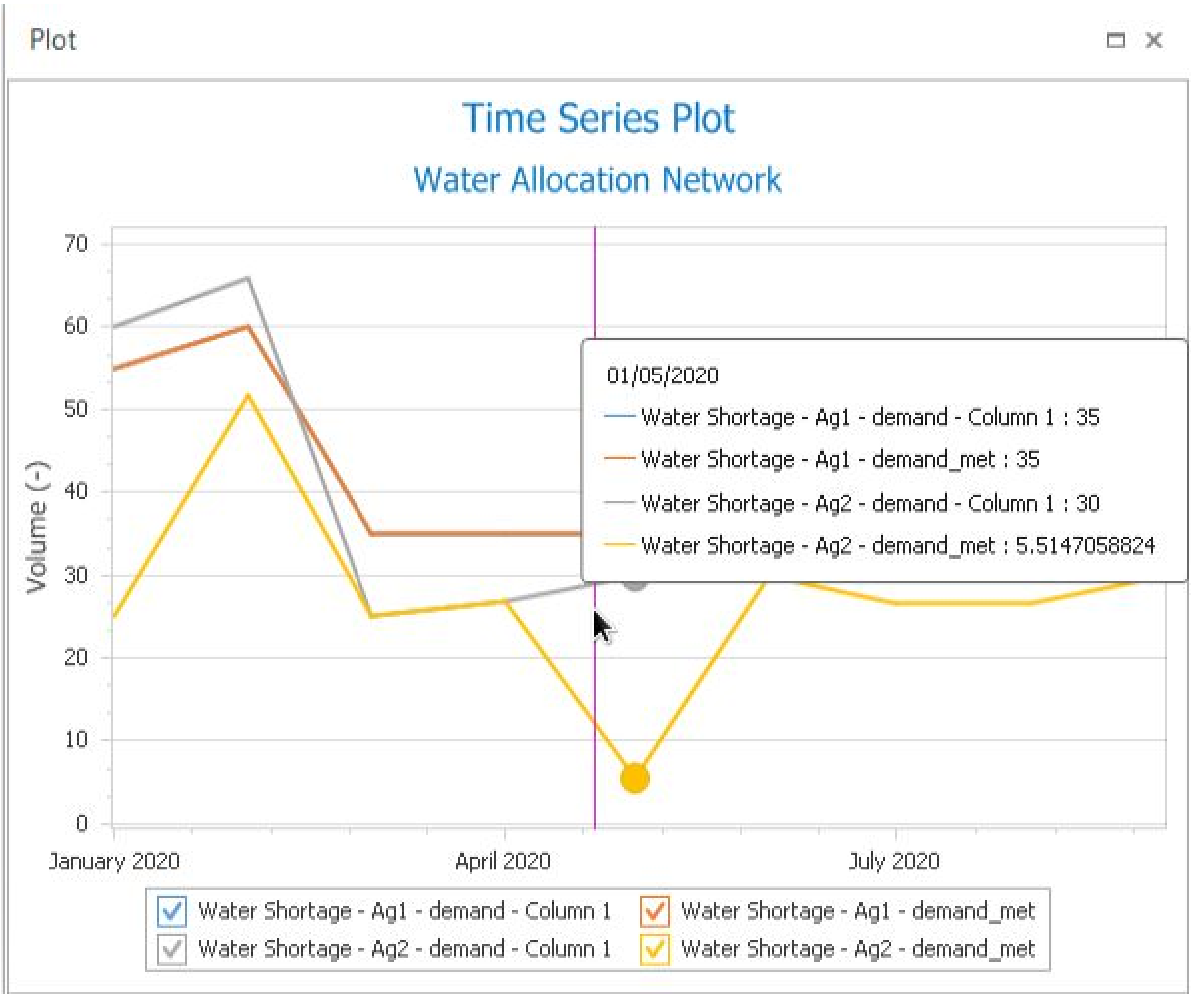
- Call the new scenario 'Water Shortage'.
- Ensure that the network 'Water Allocation Network' is chosen, and so is the template:



- Press 'Run' and wait for the import to complete.
- Ensure the ''Water Shortage' scenario is active.
- Now re-run the GAMS model, except this time choosing the 'Water Shortage' scenario:



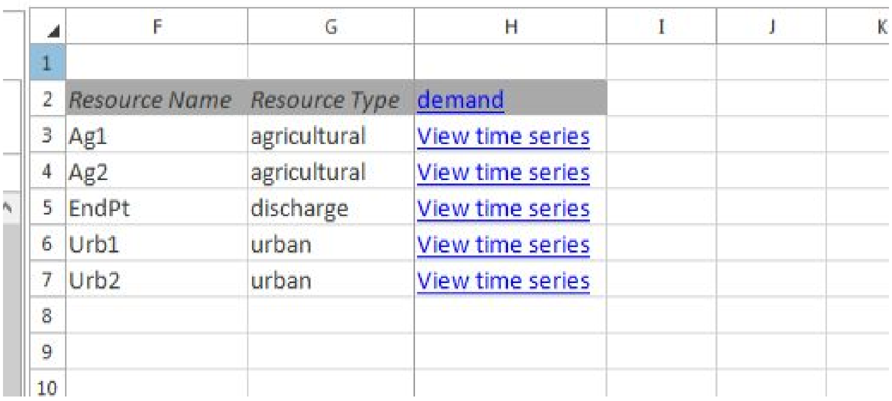
- Once complete, we can compare the results of the two scenarios. As before, select the demand and demand_met for both the agricultural nodes, pressing ‘Time Series -> General’ each time. The graph should look like this:



Note how the demand_met for Ag2 on the 1st of May is 5.5 whereas the demand is 30. AG1 is unaffected by the shortage.

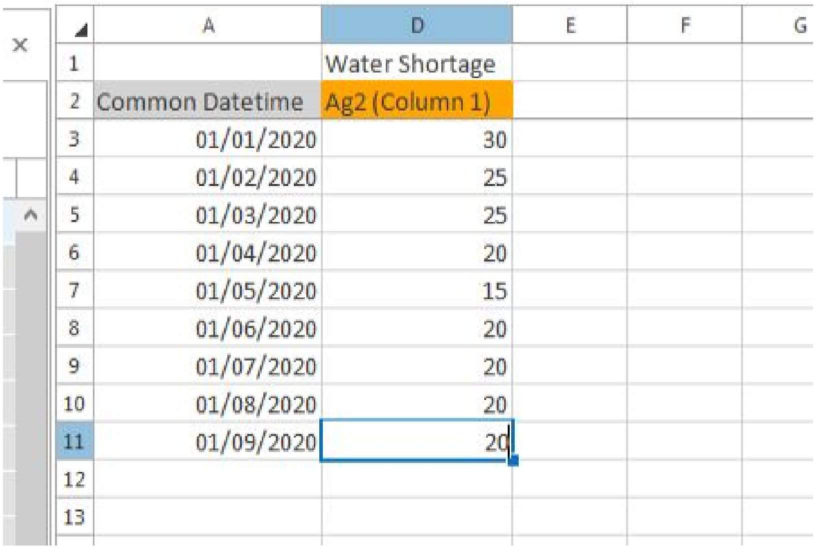
Several approaches can be taken to deal with this shortage. We will implement a 'demand reduction', where we reduce the demand for water by AG2.

- In the 'home' tab', click on 'Scenario Manager'
- Click on the check-box 'demand' on the left, followed by 'Extract Data' at the top (see getting started if you are unsure).
- Now click on 'View Time Series' beside 'AG2'



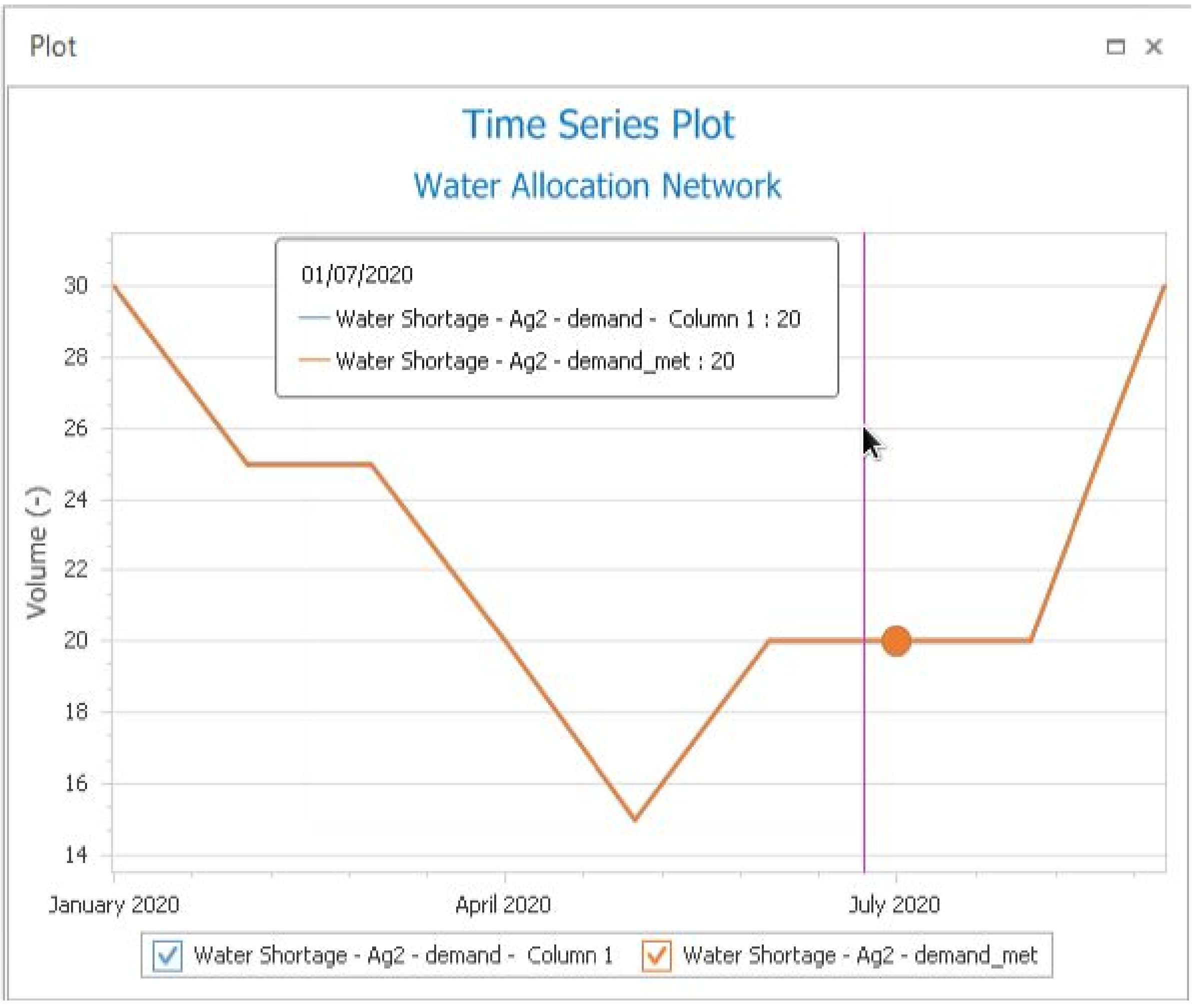
	F	G	H	I	J	K
1						
2	Resource Name	Resource Type	demand			
3	Ag1	agricultural	View time series			
4	Ag2	agricultural	View time series			
5	EndPt	discharge	View time series			
6	Urb1	urban	View time series			
7	Urb2	urban	View time series			
8						
9						
10						

- Now reduce the demand values like so (Note how the top goes orange). This means that values have changed but are unsaved. You must save the changes using the ‘save changes’ button at the top.



	A	D	E	F	G
1		Water Shortage			
2	Common Datetime	Ag2 (Column 1)			
3	01/01/2020	30			
4	01/02/2020	25			
5	01/03/2020	25			
6	01/04/2020	20			
7	01/05/2020	15			
8	01/06/2020	20			
9	01/07/2020	20			
10	01/08/2020	20			
11	01/09/2020	20			
12					
13					

- Now re-run the model and inspect the demand vs demand met for AG2. Note how the demand is now met for ag2 at each time step. The demand reduction policy worked!



Plot
Time Series Plot
Water Allocation Network
01/07/2020
Water Shortage - Ag2 - demand - Column 1 : 20
Water Shortage - Ag2 - demand_met : 20
Volume (-)
30
28
26
24
22
20
18
16
14
January 2020
April 2020
July 2020
Water Shortage - Ag2 - demand - Column 1
Water Shortage - Ag2 - demand_met