A Guide to Aquator

5 Constraints

Version 2.1

By Oxford Scientific Software Ltd.

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Constraints

Aquator Standard Constraints

The following are a list of the standard Aquator constraints.

 Annual Licence

 Annual Yield

 Availability constraint

 Daily Licence

 Period Licence

 Rolling Licence

 Seasonal Licence

Annual Licence

An annual licence restricts the amount of water that a source can release to an annual maximum quantity.

At the start of the new licence year, the licence amount left is reset to the annual licence amount. The licence can start on the first day of any month.

This constraint always maintains enough in reserve to meet the sum of all minimum supply requirements to the end of the licence period.

This constraint reports ‘excess water’ available only when the use rate so far into the licence year is below the ‘normal’ use rate. The ‘normal use’ rate is the annual licence amount divided by the number of days in the year.

Properties

A constraint only has one set of properties. Properties do not change during a model run.

Group	Name
Constraint	Display Name

Parameters

A constraint can have more than one set of parameters. Parameters do not change during a model run.

Group	Name
Options	Enabled
	Events on
	Trace on
	Trace flags
Licence	Amount
	Start month
	Enforce

States

A constraint can have more than one set of states. The value of a state variable may be different at the end of a model run to its value at the start.

Group	Name
Licence	Amount left

Variables

A constraint can have more than one set of variables. Variables are possible daily outputs from the constraint and may be turned on and off.

Group	Name
Quantity	Taken today
	Left
	Used
Percent	Left
	Used
Operation	Resource state
	Status level

Sequences

A constraint can have more than one set of sequences. Sequences are a requirement, sometimes optional, of the constraint for daily values of data. These data are supplied by a time series (potentially a different value every day) or a profile (series repeating annually).

There are no sequences for this type of constraint.

Interfaces

An interface defines a fixed set of instructions to which the constraint responds. During this response by the constraint, it is possible for the VBA programmer to modify this response to customise the way model operates.

Name
IBaseObject

Name
IConstraint
ILicence

Resource State

The resource state of this constraint is zero if there is no licence left. The resource state is one if the use rate so far this year is ‘normal’, less than one if the use rate is greater than normal and greater than one if the use rate is less than normal. The ‘normal use’ rate is the annual licence amount divided by the number of days in the year.

Status level

This constraint type always reports an end of day status level of ‘OK’ (value = 0) unless changed by the VBA programmer.

Annual Yield

An annual yield constraint restricts the amount of water that a source can release to an annual maximum quantity.

At the start of the new yield year, the yield amount left is reset to the annual yield amount. The yield year can start on the first day of any month.

This constraint always maintains enough in reserve to meet the sum of all minimum supply requirements to the end of the licence period.

This constraint reports ‘excess water’ available only when the use rate so far into the yield year is below the ‘normal’ use rate. The ‘normal use’ rate is the annual yield amount divided by the number of days in the year.

Properties

A constraint only has one set of properties. Properties do not change during a model run.

Group	Name
Constraint	Display Name

Parameters

A constraint can have more than one set of parameters. Parameters do not change during a model run.

Group	Name
Options	Enabled
	Events on
	Trace on
	Trace flags
Yield	Amount
	Start month
	Enforce

States

A constraint can have more than one set of states. The value of a state variable may be different at the end of a model run to its value at the start.

Group	Name
Yield	Amount left

Variables

A constraint can have more than one set of variables. Variables are possible daily outputs from the constraint and may be turned on and off.

Group	Name
Quantity	Taken today
	Left
	Used
Percent	Left
	Used
Operation	Resource state
	Status level

Sequences

A constraint can have more than one set of sequences. Sequences are a requirement, sometimes optional, of the constraint for daily values of data. These data are supplied by a time series (potentially a different value every day) or a profile (series repeating annually).

There are no sequences for this type of constraint.

Interfaces

An interface defines a fixed set of instructions to which the constraint responds. During this response by the constraint, it is possible for the VBA programmer to modify this response to customise the way model operates.

Name
IBaseObject
IConstraint
ILicence

Resource State

The resource state of this constraint is zero if there is no yield left. The resource state is one if the use rate so far this year is ‘normal’, less than one if the use rate is greater than normal and greater than one if the use rate is less than normal. The ‘normal use’ rate is the annual yield amount divided by the number of days in the year.

Status level

This constraint type always reports an end of day status level of ‘OK’ (value = 0) unless changed by the VBA programmer.

Availabity Constraint

The availability constraint determines on a day by day basis whether a source can supply water. This constraint is controlled by a boolean quantity taking the value True if water can be supplied, or False if water cannot be supplied. When set to True, the constraint does not limit the supply of water in any way. When set to False, no water can be supplied.

In order of preference, the availability on any day is set by:

The *Availability* Time series sequence if assigned

The *Availability* Profile sequence if assigned

The *Supply.Available* Parameter

If the availability is determined by a relationship that depends on factors that vary during a model run, the *Supply.Available* (or P_Available) parameter may be used as the means of control with the parameter value set to True or False using VBA code.

Properties

A constraint only has one set of properties. Properties do not change during a model run.

Group	Name
Constraint	Display Name

Parameters

A constraint can have more than one set of parameters. Parameters do not change during a model run.

Group	Name
Options	Enabled
	Events on
	Trace on
	Trace flags
Supply	Available

States

A constraint can have more than one set of states. The value of a state variable may be different at the end of a model run to its value at the start.

There are no states for this type of constraint.

Variables

A constraint can have more than one set of variables. Variables are possible daily outputs from the constraint and may be turned on and off.

Group	Name
Operation	Available
	Status level

Sequences

A constraint can have more than one set of sequences. Sequences are a requirement, sometimes optional, of the constraint for daily values of data. These data are supplied by a time series (potentially a different value every day) or a profile (series repeating annually).

Name	Time series	Profile
Available	Optional	Optional

Available

This sequence is a set of Boolean (True or False) values that define supply availability on each day of the model run. True is defined by the numeric value –1; False by the numeric value 0 (zero).

Interfaces

An interface defines a fixed set of instructions to which the constraint responds. During this response by the constraint, it is possible for the VBA programmer to modify this response to customise the way model operates.

Name
IBaseObject
IConstraint

Name
ILicence

Resource State

The resource state of this constraint is zero if not available today, otherwise there is no resource state.

Status level

This constraint type always reports an end of day status level of 'OK' (value = 0) unless changed by the VBA programmer.

Daily Licence

A daily licence constraint restricts the amount of water that a source can release to the daily maximum quantity which can be defined as a fixed parameter or a value which varies throughout the model run by using a profile or time series.

The daily licence controlled by a sequence is different to a seasonal licence. The latter tries to ensure even use of the licence over the specified season. The former simply limits the amount that is supplied day by day.

Properties

A constraint only has one set of properties. Properties do not change during a model run.

Group	Name
Constraint	Display Name

Parameters

A constraint can have more than one set of parameters. Parameters do not change during a model run.

Group	Name
Options	Enabled
	Events on
	Trace on

Group	Name
	Trace flags
Licence	Amount

States

A constraint can have more than one set of states. The value of a state variable may be different at the end of a model run to its value at the start.

There are no states for this type of constraint..

Variables

A constraint can have more than one set of variables. Variables are possible daily outputs from the constraint and may be turned on and off.

Group	Name
Quantity	Taken today
	Left
Operation	Status level

Sequences

A constraint can have more than one set of sequences. Sequences are a requirement, sometimes optional, of the constraint for daily values of data. These data are supplied by a time series (potentially a different value every day) or a profile (series repeating annually).

Name	Time series	Profile
Licence amount	Optional	Optional

Licence amount

The maximum amount that can be supplied on any day. If both the time series and profile are defined, the time series is used in preference. If nether are defined the parameter *Licence.Amount* is used.

Interfaces

An interface defines a fixed set of instructions to which the constraint responds. During this response by the constraint, it is

possible for the VBA programmer to modify this response to customise the way model operates.

Name
IBaseObject
IConstraint
ILicence

Resource State

This constraint does not have a resource state.

Status level

This constraint type always reports an end of day status level of ‘OK’ (value = 0) unless changed by the VBA programmer.

Period Licence

A Period licence operates over a period defined in months from a the first day of a specified start month. For example a quarterly licence would be defined as 3 months long and start in January. Periods run sequentially, so in the example given the same licence amount would be available between April and June as between January and March. Periods may be greater than one year. For example a 5 year licence can be set up by specifying a period of 60 months.

Aquator attempts to make optimum use of these licences by setting their resource state above one when usage is below 'normal' for each day during the period, and setting it to below one when usage is above 'normal' to date.

Properties

A constraint only has one set of properties. Properties do not change during a model run.

Group	Name
Constraint	Display Name

Parameters

A constraint can have more than one set of parameters. Parameters do not change during a model run.

Group	Name
Options	Enabled
	Events on
	Trace on
	Trace flags
Licence	Months
	Start month
	Start year
	Amount
	Enforce

States

A constraint can have more than one set of states. The value of a state variable may be different at the end of a model run to its value at the start.

Group	Name
Licence	Amount left

Variables

A constraint can have more than one set of variables. Variables are possible daily outputs from the constraint and may be turned on and off.

Group	Name
Quantity	Taken today
	Left
	Used
Percent	Left
	Used
Operation	Resource state
	Status level

Sequences

A constraint can have more than one set of sequences. Sequences are a requirement, sometimes optional, of the constraint for daily values of data. These data are supplied by a time series (potentially a different value every day) or a profile (series repeating annually).

There are no sequences for this type of constraint.

Interfaces

An interface defines a fixed set of instructions to which the constraint responds. During this response by the constraint, it is possible for the VBA programmer to modify this response to customise the way model operates.

Name
IBaseObject

Name
IConstraint
ILicence

Resource State

The resource state of this constraint is described in the *Variables* section.

Status level

This constraint type always reports an end of day status level of ‘OK’ (value = 0) unless changed by the VBA programmer.

Rolling Licence

A rolling licence is renewed annually but considers amounts supplied over a period which is greater than one year. For example a 5 year rolling licence, that starts in January will set the maximum cumulative abstraction that can take place over the next twelve month to be:

5 year licence amount – Abstraction over the 4 years prior to the January renewal

Another example might be an 18 month rolling licence, renewed in April. Here the amount in the licence for the 12 month period to the end of March next is:

18 month licence amount – Cumulative abstraction from 1st October the previous year until 31st March.

This type of constraint may be used when full use of an annual licence amount over several years is succession is unacceptable, but full use in a drought year is permissible. Typically the value of the rolling licence divided by its period will be less than the value of the annual licence.

Clearly best use is made of this type of licence if a quantity is held in reserve at the end of each 'normal' or 'wet' year, so that the full use of any other licence can be made during a 'drought' year. If the parameter *Licence.Reserve amount* is set to a positive amount, Aquator will attempt to leave this amount in the licence before each annually renewal. This is done by allowing for the reserve amount in the calculation of the licence's resource state.

As an example assume a 5 year licence with a value of 150,000 Ml and the next limiting factor was the annual licence of 33,000 Ml. If a reserve was needed to allow for two successive drought years, a sensible reserve amount would be (33,000 - (150,000 ÷ 5)) x 2 = 6,000 Ml.

Properties

A constraint only has one set of properties. Properties do not change during a model run.

Group	Name
Constraint	Display Name

Parameters

A constraint can have more than one set of parameters. Parameters do not change during a model run.

Group	Name
Options	Enabled
	Events on
	Trace on
	Trace flags
Licence	Start month
	Amount
	Reserve amount
	Enforce

States

A constraint can have more than one set of states. The value of a state variable may be different at the end of a model run to its value at the start.

Group	Name
Licence	Months
	Usage history

Variables

A constraint can have more than one set of variables. Variables are possible daily outputs from the constraint and may be turned on and off.

Group	Name
Quantity	Taken today
	Left
	Used
Percent	Left
	Used
Operation	Resource state
	Status level

Sequences

A constraint can have more than one set of sequences. Sequences are a requirement, sometimes optional, of the constraint for daily values of data. These data are supplied by a time series (potentially a different value every day) or a profile (series repeating annually).

There are no sequences for this type of constraint.

Interfaces

An interface defines a fixed set of instructions to which the constraint responds. During this response by the constraint, it is possible for the VBA programmer to modify this response to customise the way model operates.

Name
IBaseObject
IConstraint
ILicence

Resource State

The resource state of this constraint is described the *Variables* section.

Status level

This constraint type always reports an end of day status level of 'OK' (value = 0) unless changed by the VBA programmer.

Seasonal Licence

A season licence only comes into effect between two dates in a year. Outside that period there this constraint does not limit supply. Multiple season licences might be set up covering different periods in the year. For example a summer licence might be set up to run April 15th to September 30th and have a value which would determine the maximum quantity of water that could be supplied in that period. A corresponding winter licence might be set up to run from October 1st to April 14th and attached to the same component.

Aquator attempts to make optimum use of these licences by setting their resource state above one when usage is below 'normal' for each day during the licence period, and setting it to below one when usage is above 'normal' to date. This control is more sophisticated that attaching a sequence to a daily licence which simply limits the amount that can be abstracted to a variable maximum quantity each day.

Properties

A constraint only has one set of properties. Properties do not change during a model run.

Group	Name
Constraint	Display Name

Parameters

A constraint can have more than one set of parameters. Parameters do not change during a model run.

Group	Name
Options	Enabled
	Events on
	Trace on
	Trace flags
Licence	Start day
	Start month
	End day

Group	Name
	End month
	Amount
	Enforce

States

A constraint can have more than one set of states. The value of a state variable may be different at the end of a model run to its value at the start.

Group	Name
Licence	Amount left

Variables

A constraint can have more than one set of variables. Variables are possible daily outputs from the constraint and may be turned on and off.

Group	Name
Quantity	Taken today
	Left
	Used
Percent	Left
	Used
Operation	In season
	Resource state
	Status level

Sequences

A constraint can have more than one set of sequences. Sequences are a requirement, sometimes optional, of the constraint for daily values of data. These data are supplied by a time series (potentially a different value every day) or a profile (series repeating annually).

There are no sequences for this type of constraint.

Interfaces

An interface defines a fixed set of instructions to which the constraint responds. During this response by the constraint, it is possible for the VBA programmer to modify this response to customise the way model operates.

Name
IBaseObject
IConstraint
ILicence

Resource State

The resource state of this constraint is described the *Variables* section.

Status level

This constraint type always reports an end of day status level of 'OK' (value = 0) unless changed by the VBA programmer.

Properties

A *Property* is a value for a Component which has no hydrological significance. For example, the co-ordinates of a Component on the schematic and the colours used to render the Component's icon.

Constraint.Display name

The name that appears to the user. This name may be changed.

Parameters

A *Parameter* is a value for a Component which affects its behaviour during a model run, but which typically does not change during a run, and often is not changed between runs. For example: the stage-area-volume curves of a Reservoir would not normally be altered frequently.

Licence.Amount (Annual licence)

The annual licence amount

Licence.Amount (Daily licence)

The daily licence amount.

Licence.Amount (Period licence)

The period licence amount.

Licence.Amount (Rolling licence)

The value of the licence over its whole period.

Licence.Amount (Season licence)

The value of the licence over the season.

Licence.End day

End day of the licence.

Licence.End month

End month of the licence. The start date may be after the end date to allow for seasons that span the calendar year end.

Licence.Enforce

Set to True for normal use of the licence – i.e. not water is supplied once the licence has expired and any water taken reduces the licence by the same amount.

Set to False to effectively remove the licence – i.e. water is supplied even if the licence is used up and any water taken does not reduce the amount left in the licence.

The main purpose of this parameter is to enable VBA to turn on the licence for some abstractions and turn off the licence for other abstractions.

Licence.Months

Length of the period which must be at least one month.

Licence.Reserve amount

The amount to try and reserve at the end of each year. The licence will have a resource state of 1 at the end of the year if this amount is left in the licence.

Licence.Start day

Start day of the licence.

Licence.Start month (Annual licence)

The month from which the annual licence starts. On the first day of this month, the amount left in the annual licence is reset to its licence value.

Licence.Start month (Period licence)

Start month of the licence.

Licence.Start month (Rolling licence)

Start month of the licence. The licence is renewed annually on the first day of this month.

Licence.Start month (Season licence)

Start month of the licence. The start date may be after the end date to allow for seasons that span the calendar year end.

Licence.Start year (Period licence)

Start year of the licence. This is only effective if the number of months specified for the period is non repetitive in subsequent years. E.g. 5 months or 18 months.

Options.Enabled

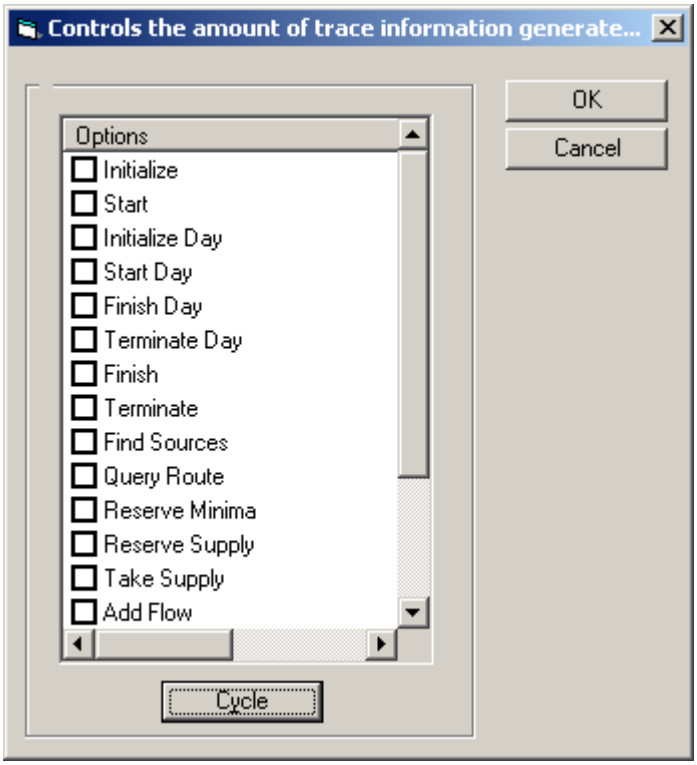
When enabled the constraint operates normally. Setting this option to ‘False’ effectively removed the constraint during model execution.

Options.Events on

When set to ‘True’ any Visual Basic (VBA) code attached to the constraint will be executed. If you have no VBA code then it is a good idea to set this option to ‘False’ as this will improve model performance.

Options.Trace flags

This option allows the trapping of specific events during a model run on a constraint by constraint basis. The following dialog box is displayed to allow the events to be specified:



Options.Trace on

When set to 'True', constraint events are logged in the 'Trace log'. This is useful when debugging a system to ensure it is behaving as required. It is more efficient in terms of model execution time to have this option set to 'False'

Supply. Available

Set to True to allow an unrestricted amount of water. Set to False to prevent any supply of water.

As the value stays the same for the whole model run, the main purpose of this parameter is that it can be set dynamically during model execution using VBA.

Yield.Amount

The annual yield amount

Yield.Enforce

Set to True for normal use of the yield – i.e. not water is supplied once the yield is exhausted and any water taken reduces the yield by the same amount.

Set to False to effectively remove the yield restriction – i.e. water is supplied even if the yield is zero and any water taken does not reduce the amount left in the yield.

The main purpose of this parameter is to enable VBA to turn on the yield restriction for some abstractions and turn off the yield restriction for other abstractions.

Yield.Start month

The month from which the annual yield starts. On the first day of this month, the amount left in the annual yield is reset to its yield value.

States

A value for a Component or the model which affects its behaviour during a model run, and which typically does change during the run, and often is changed between runs. For example: the initial storage of a Reservoir on the first day of the run would typically vary from run to run.

Licence.Amount left (Annual licence)

The amount left in the annual licence

Licence.Amount left (Period licence)

The amount left in the period licence.

Licence.Amount left (Season licence)

The amount left in the season licence.

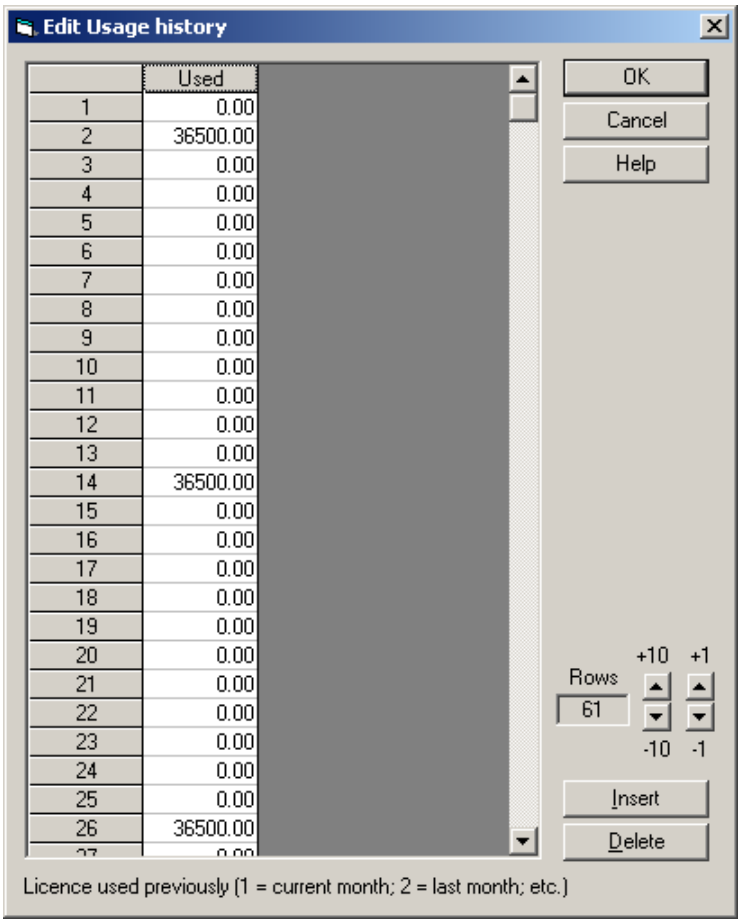
Licence.Months

The number of months defining the period of the licence. For example a 5 year licence would need this parameter to be set to 60. The parameter must be set to a value of at least 13.

Licence.Usage history

This is an array of current and past monthly usage of the licence and is necessary to determine the renewal quantity at the start of each year. There is one more element to this array than there are months in the licence period to allow for any existing use in the first month of the model run. A 5 year licence will therefore have an array of 61 elements. Element 1 is current month usage, element 2, last month etc. If historic monthly licence usage is not available, use so far this year and pervious annual totals may be placed in an appropriate monthly element. The following shows

the states set up for a 5 year licence staring in January for a run starting on 1st January.



Element 1 is the used in the first month of the model run (zero). Element 2 is the total amount used in the preceding year (36500). This has been placed in the December element, but could be inserted in any of the elements 2 to 13. Element 14 holds the amount for the year before last in the same way.

If state values are saved during the model run, Aquator will have inserted the correct monthly totals in each month, not just the annual totals which are more convenient for manual entry.

Yield.Amount left

The amount left in the annual yield

Variables

A value for a Component which is computed daily during a model run. This can include both predicted and observed values i.e. a sequence of observed storage linked to a Reservoir Component can be captured in a variable so that both observed and calculated storage can be plotted on the same chart.

Operation.Available

A Boolean sequence of True or False values that defined whether or not the supply was available on each day of the model run. True values are defined by the value –1; False values by 0 (zero).

Operation.In season

A Boolean value (True = -1, False = 0) stating whether or not each day of the model run was in the season or outside the season.

Operation.Resource state

The state of the resource at the constraint at the beginning of the day (i.e. before any water has been taken). A resource state of 1 is 'normal'; values greater than 1 indicate the resource is in a better than normal state. A resource state less than 1 indicates the resource is in a worse state than normal If the resource state is greater than 1, the constraint is then able to supply water on Pass 4 (i.e. when least cost water is being sought).

Operation.Status level

The status level reported by this constraint at the end of the day. Status level can be one of the following:

Level	Description
0	OK
1	Warning
2	Failure
3	Error

Percent.Left

Percent of constraint amount left

Percent.Used

Percent of the constraint amount used so far.

Quantity.Left

Quantity of water left in the constraint.

Quantity.taken today

Amount of water taken from constraint per day

Quantity.Used

Quantity of water used from the constraint so far.

Sequences

A *Sequence* is a requirement for daily data during a model run. Sequential data must be supplied to a Constraint in order for the Constraint to operate correctly. Not all Constraints require Sequences.