



## Featured Article

### FASTER SBR SIMULATIONS IN 3.1

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In this edition of *The BioWin Advantage*, we'll begin to explore some of the new features that are incorporated in BioWin 3.1. First up...faster SBR simulations!

## Faster SBR simulations in 3.1

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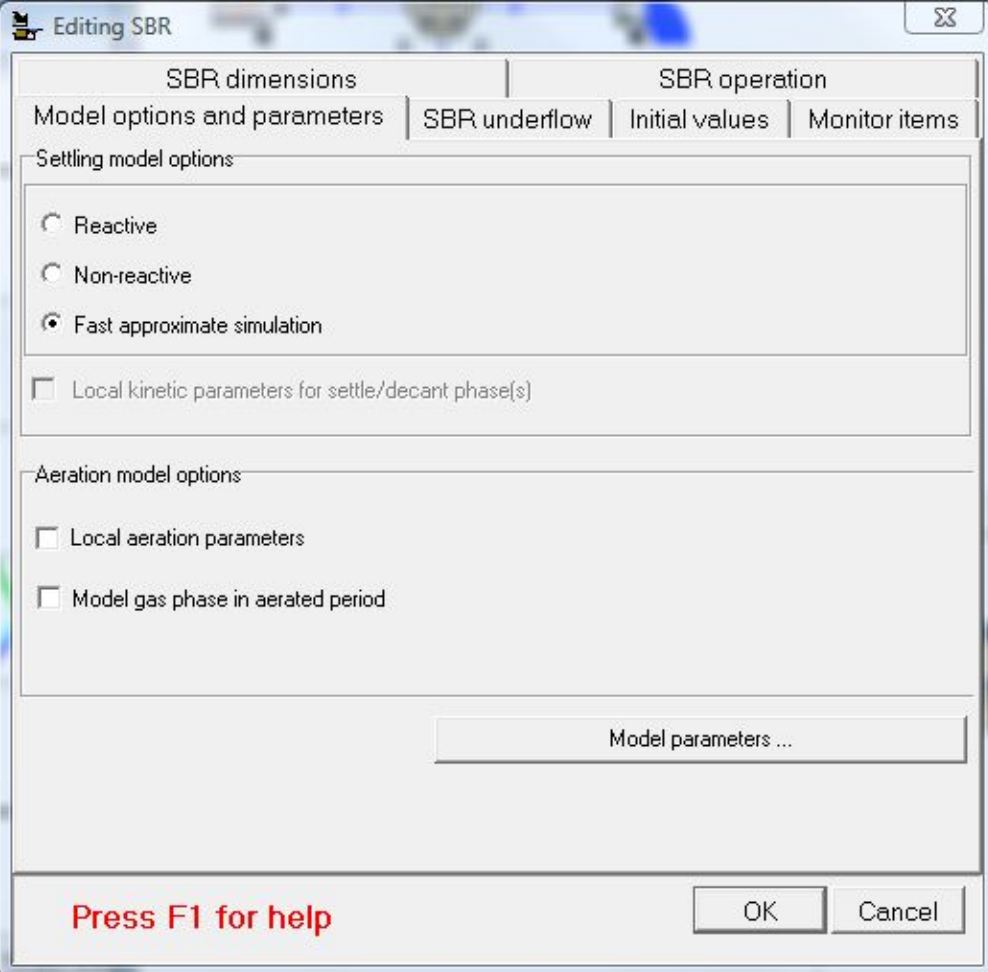
Sequencing Batch Reactors (SBRs) enjoy a wide application in wastewater treatment and BioWin uses a comprehensive quasi two-dimensional modelling approach to most accurately represent these systems. The inherently dynamic nature of SBR systems makes the application of steady state techniques inappropriate, and the complexity of the BioWin biological and chemical model in combination with a two dimensional approach can result in slow dynamic simulations. This issue of *The BioWin Advantage* looks at the new "simplified" approach to modelling SBR systems available in BioWin 3.1 which can dramatically reduce the time required to perform these simulations. We also investigate the situations in which this simplified approach is most applicable.

## Simplified... but how?

In BioWin's quasi two-dimensional approach, when an SBR is in settling mode the reactor volume is divided into a grid of individual cells, each modelled as a biological settling zone. In a single tank SBR this results in 30 individual biological settling zones, each of which is performing all of the BioWin biological, chemical and settling operation calculations. This is very computationally demanding and may result in decreased simulation speed for SBR systems (compared to simulation of conventional activated sludge systems). The benefit of this approach, however, is the ability to capture phenomena such as short-circuiting in continuous feed systems which is not possible in other simulators. In BioWin 3.1 there is now an option to choose a "simplified" approach when simulating the settling mode of an SBR. This option is called the "Fast approximate simulation" and tells BioWin to **only** consider the settling operations that are occurring. Since no biology or chemistry is required, BioWin only needs to consider the total solids concentration (not the individual state variables) and consequently the simulation calculations can be done much more rapidly.

## Using the simplified approach.

The "Fast approximate simulation" approach is selected on a reactor by reactor basis allowing you to mix "Fast" and "Reactive" simulation approaches in a single file. To select the "Fast approximate simulation", open the SBR properties, click on the tab titled "Model options and parameters" and choose the appropriate radio button as shown below:



**FIGURE 1: SBR Model options and parameters**

### How fast is fast?

The "Fast approximate simulation" approach can result in significant reduction in simulation times. Some relative simulation times (for the standard example SBR systems that ship with BioWin) are shown below (in each case the simulations were performed starting from seed conditions).

**TABLE 1: Impact on simulations speed**

Model Layout and Simulation	Method	Simulation time (m:s)
Fill and draw start-up (60 days from seed)	Reactive	6:12
	Simplified	0:52
Two SBRs settle prezone (30 days from seed)	Reactive	25:03
	Simplified	10:59
Four SBRs (30 days from seed)	Reactive	78:13
	Simplified	12:15

### Is there a catch?

The fast approximate method does not do **any** reactions during the settling phase and considers only the total solids concentration for settling[1] calculations. This means that the concentration of components like oxygen and nitrate, which would likely change during settling (particularly near the bottom of the tank) are not impacted by

the settling process. Also, the fact that only solids concentrations are considered during settling means if there is any flow into or out of the tank during the settling period some mass balance errors will occur[2]. However, as we'll see in the next section, in many cases the simplified settling approach can be used to rapidly approach the steady state condition with very reasonable accuracy. At that point, running the simulation a bit further with the full reactive model will finish the job.

[1] Many other commercially available simulators only offer this method.

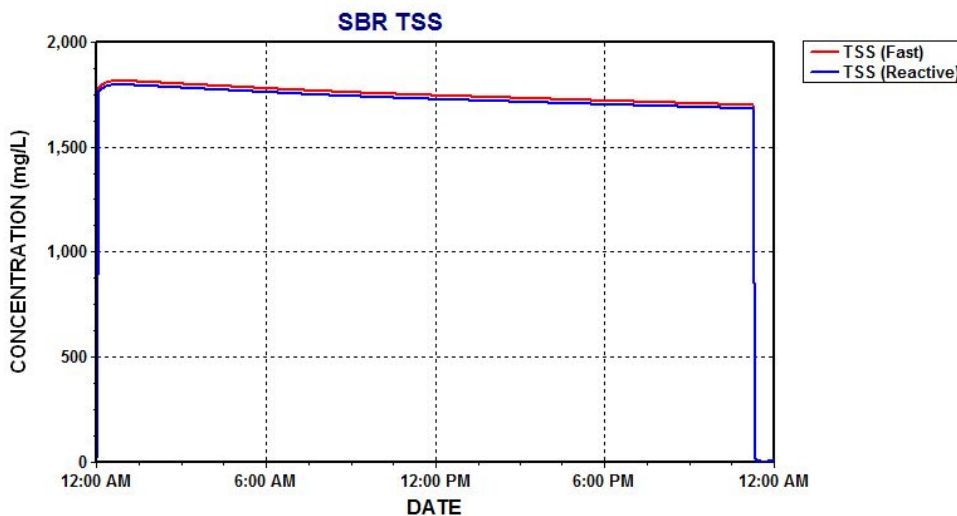
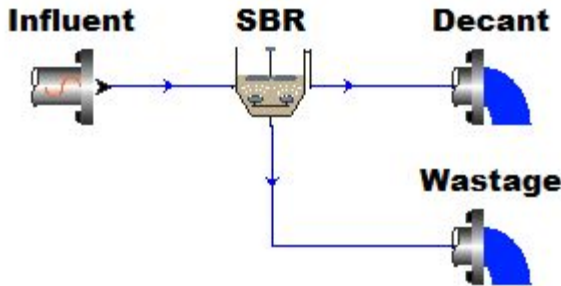
[2] For the rest of this discussion we will assume that the "Fast approximate simulation" is not being used for situations with feed during the settle period because it will result in a mass balance error.

## Comparing the results

The biggest difference between the full "Reactive" and "Fast approximate" simulations will be the impact of reactions during the settling phase. The two extremes of these are (1) reactions at the full rates during the settling period, and (2) no reactions during the settling period.

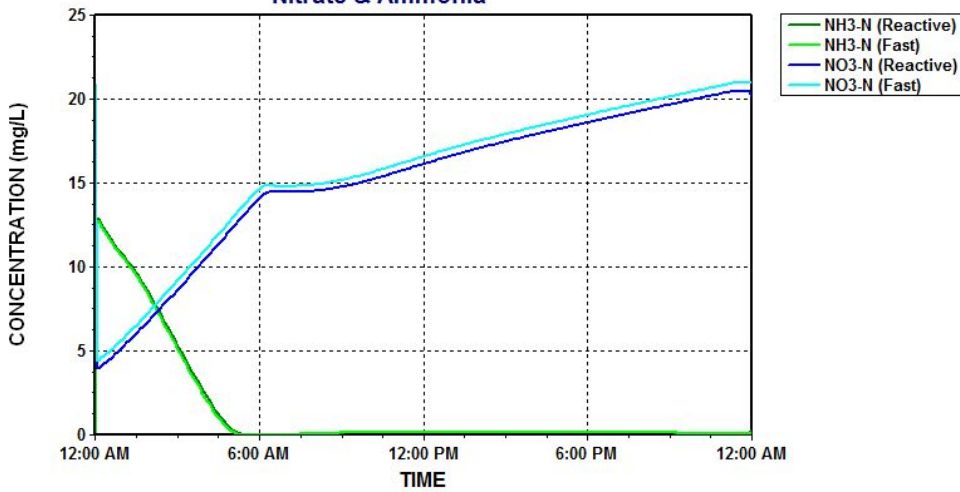
The actual performance of the system is likely to be somewhere in between these two extremes. Let's look at each of the cases summarized above in **Table 1**. The "Fill

and draw" SBR has a one day cycle time and only 45 minutes of the day are in settle mode; consequently we would expect the difference in the two methods to be the smallest in this case. The figures below show the TSS, ammonia, and nitrate responses for this system (after 59 days) and there is very little difference.



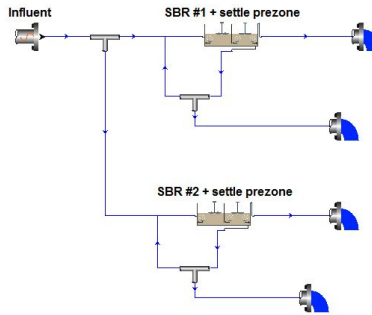
**FIGURE 2 : Fill and draw - SBR TSS response**

### Nitrate & Ammonia

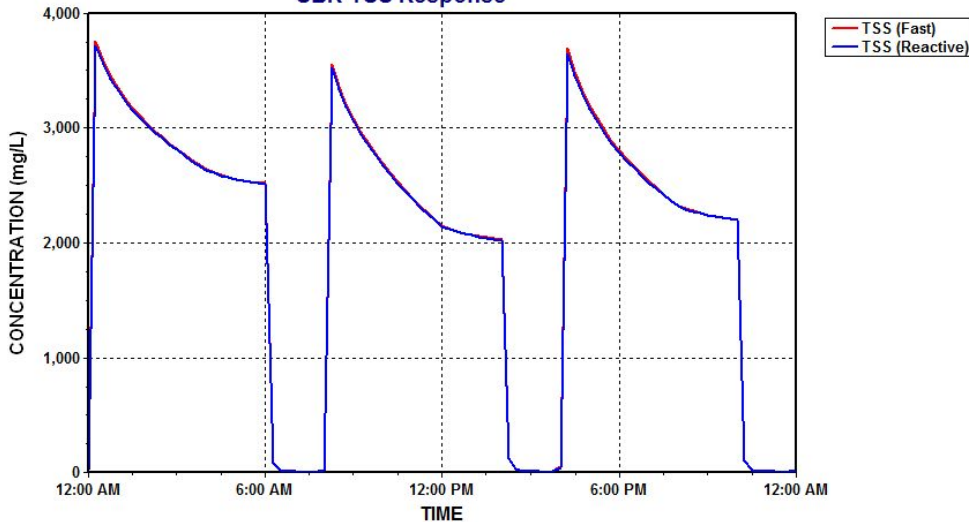


**FIGURE 3: Fill and draw -Nitrogen response**

The second example has two parallel SBR units, each with a cycle time of 8 hours and a settling time of 2 hours per cycle. In this case the settling period is a larger fraction (25%) of the total cycle time and we would expect to see a more significant difference between the two extremes of full and no reactions during settling. **Figure 4** shows the TSS response and **Figure 5** the ammonia response in the first SBR; there is little difference between the two approaches.

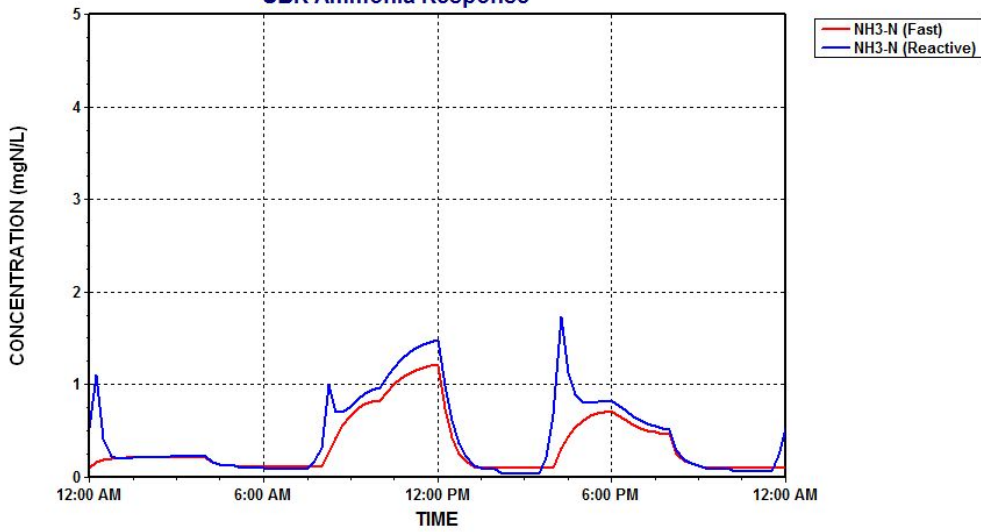


### SBR TSS Response



**FIGURE 4: Two SBRs - TSS response**

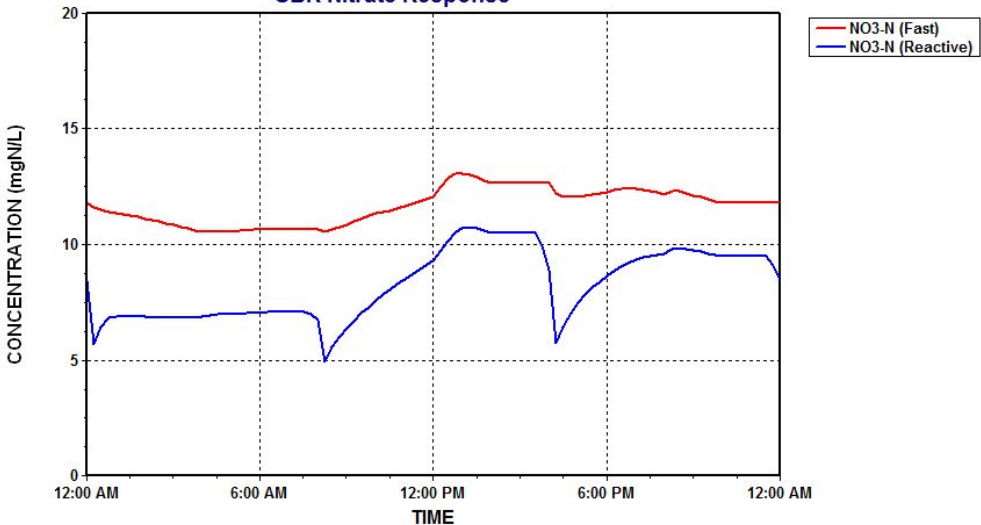
### SBR Ammonia Response



### FIGURE 5: Two SBRs - Ammonia response

However, the nitrate profile shown in Figure 6 is quite different. The "Fast approximate simulation" does not allow any denitrification during the settling period, while the "Reactive" approach does. Although the responses are somewhat different from each other, the "Fast approximate simulation" approach may still be useful in such cases because it provides a reasonable approximation quickly and further simulations can be performed which do consider the impact of reactions during the settling period if required.

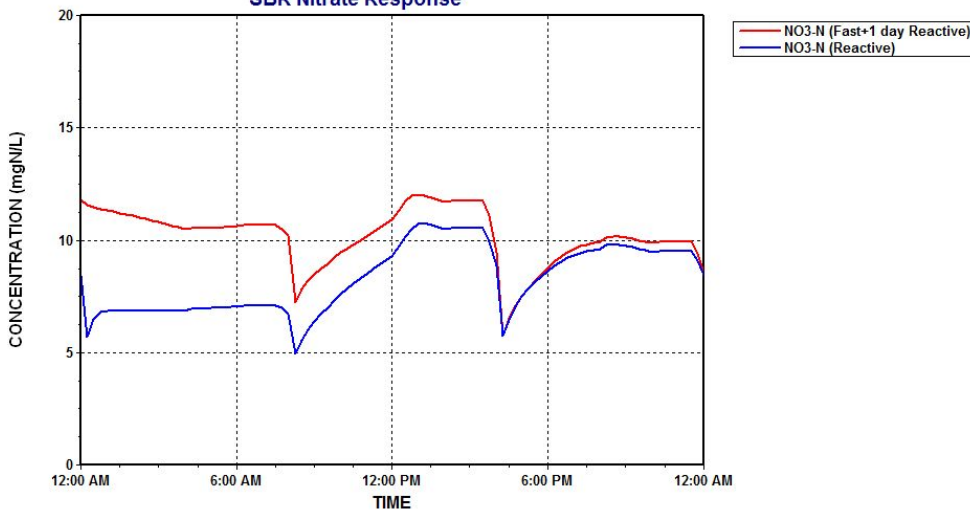
### SBR Nitrate Response



### FIGURE 6 : Two SBRs - Nitrate response

Figure 7 shows the same system, however in this case the "Reactive" method was used after the "Fast approximate" for the last day of simulation (shown). The nitrate profiles almost match after an additional day or two of simulation.

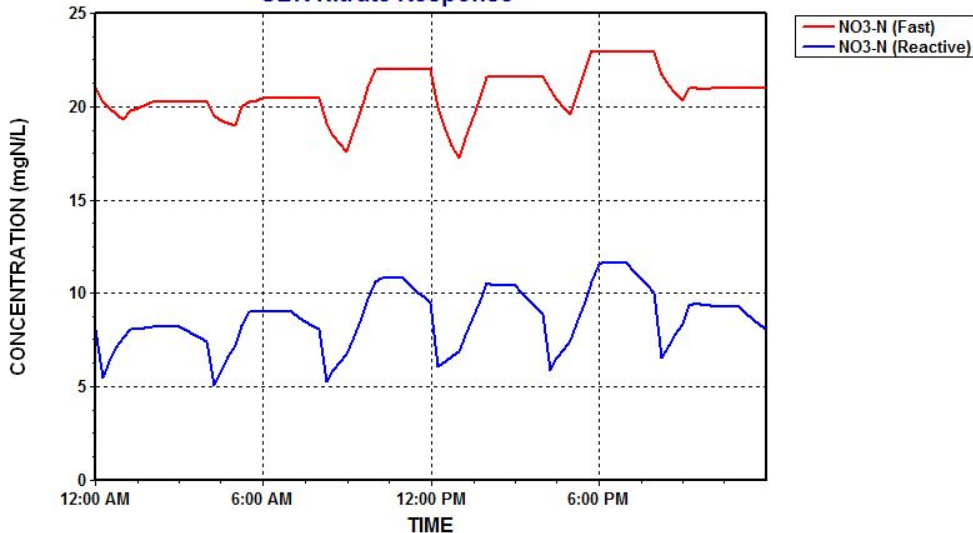
### SBR Nitrate Response



## FIGURE 7 : Two SBRs - Nitrate response + 1 day reactive

The third example has four parallel SBRs, each with a cycle time of 4 hours and a settling time of 2 hours per cycle. The settling period is half of the total cycle time so turning off reactions for half of the cycle is likely to have a marked impact. There is about a 7% difference in the TSS predictions (the approximate simulation predicts a higher solids concentration because the reactive simulation is taking into account things like anoxic growth and decay during the settling phase). The nitrate and phosphate predictions show the greatest difference. When the reactive approach is used, full reactions during the settling period use all of the oxygen and much of the nitrate. The nitrate response in **Figure 8** shows that in the fast simulation no nitrate is utilized while the reactive settling shows considerable denitrification.

### SBR Nitrate Response



## FIGURE 8 : Four SBRs - Nitrate response

### The shorter version.

The "Fast approximate simulation" option for SBRs can save lots of time, but you need to be careful when using it to be sure that it is appropriate for your situation.

1. It should **not** be used when there is in-flow during the settling period.
2. If the settling period is a large part of the cycle - then you need to be careful; it is likely that you will need to continue the simulation for some time using the full reactive model after getting in the region of the steady state with the fast method.

# In Conclusion

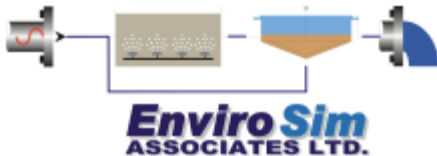
We trust that you found this technical topic both interesting and informative.

The EnviroSim Team will be issuing this collection of technical topics on a regular basis to stay in touch with our user base. User feedback drives our product development, and we're continually striving for ways to enhance and build upon that feedback.

Please feel free to contact us at [info@envirosim.com](mailto:info@envirosim.com) (Subject: The BioWin Advantage) with your comments on this article or suggestions for future article.

Thank you and good modeling

## The EnviroSim Team



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