Chapter 8

H5: Unsteady Flow through a Channel Network

Contents

8.1 Problem Specification

H5 Unsteady flow through a simple channel network

Focus network connectivity, unsteady circulation.

Channel network geometry is the same as schematic application H4. Also, use the same fixed Δt and Δx as in H4.

Open boundary conditions are

$$\eta_A(t) = \begin{cases} 0 & \text{for } t \leq 0 \\ 3 \sin \omega t & \text{for } t > 0 \end{cases} \tag{8.1.1}$$

$$Q_D(t) = 4,000 \text{ ft}^3/\text{s for all } t \tag{8.1.2}$$

$$Q_E(t) = 2,000 \text{ ft}^3/\text{s for all } t \tag{8.1.3}$$

where $\omega = 2\pi/T$, the tidal period T being 12.5 hours.

As initial conditions, use the STEADY STATE solution from Problem H4. Use a fixed computational space step $\Delta x = 500$ ft and a fixed computational time step $\Delta t = 30$ s.

Compute and write to file in the STANDARD FORMAT the initial conditions at $t = 0$ and the model predictions for every[1] time step to $t = 2T$.

8.2 Background

The context here is very similar to Problem H4, except that the investigation shifts to unsteady tidally-driven flow through the simple network.

8.3 Contra Costa Water District

CCW changed the coordinate system and the reach numbering from Figure 7.1 and Table 7.1. Reference to Tables 7.1 and 7.2 will assist in comparative interpretation of the CCW predictions.

Figures 8.1 and 8.2 shows the CCW-predicted η and Q evolution toward the steady state. These show the anticipated response to tidal forcing, namely oscillatory tidal flow superimposed on the freshwater throughflow. Initial transients are apparent in the Q evolution, but these decay with time in the expected manner. Tidal circulation reaches into upstream reaches CD (Reach # 3) and EF (Reach # 5).

Figure 8.3 shows the instantaneous flow or mass balances at junctions B, C and F. The evolution of these junction flows is expected to reflect the tidal circulation, especially at junction B during the second tidal cycle, at times $T < t \leq 2T$. The "freshwater" throughflow is large, but there are indications of tidal circulation.

The geometric context here is identical to that adopted for problem H4. Significant "truncation error" difficulties were identified in Reach CD in problem H4. Presumably, these errors are present also in problem H5. But they are not especially apparent in Figure 8.2, where they are unfortunately masked by the tidal circulation.

[1] As with H4, the data files are very large and surface plots are very dense. For the following presentations, data file entries every 300 s have been plotted.

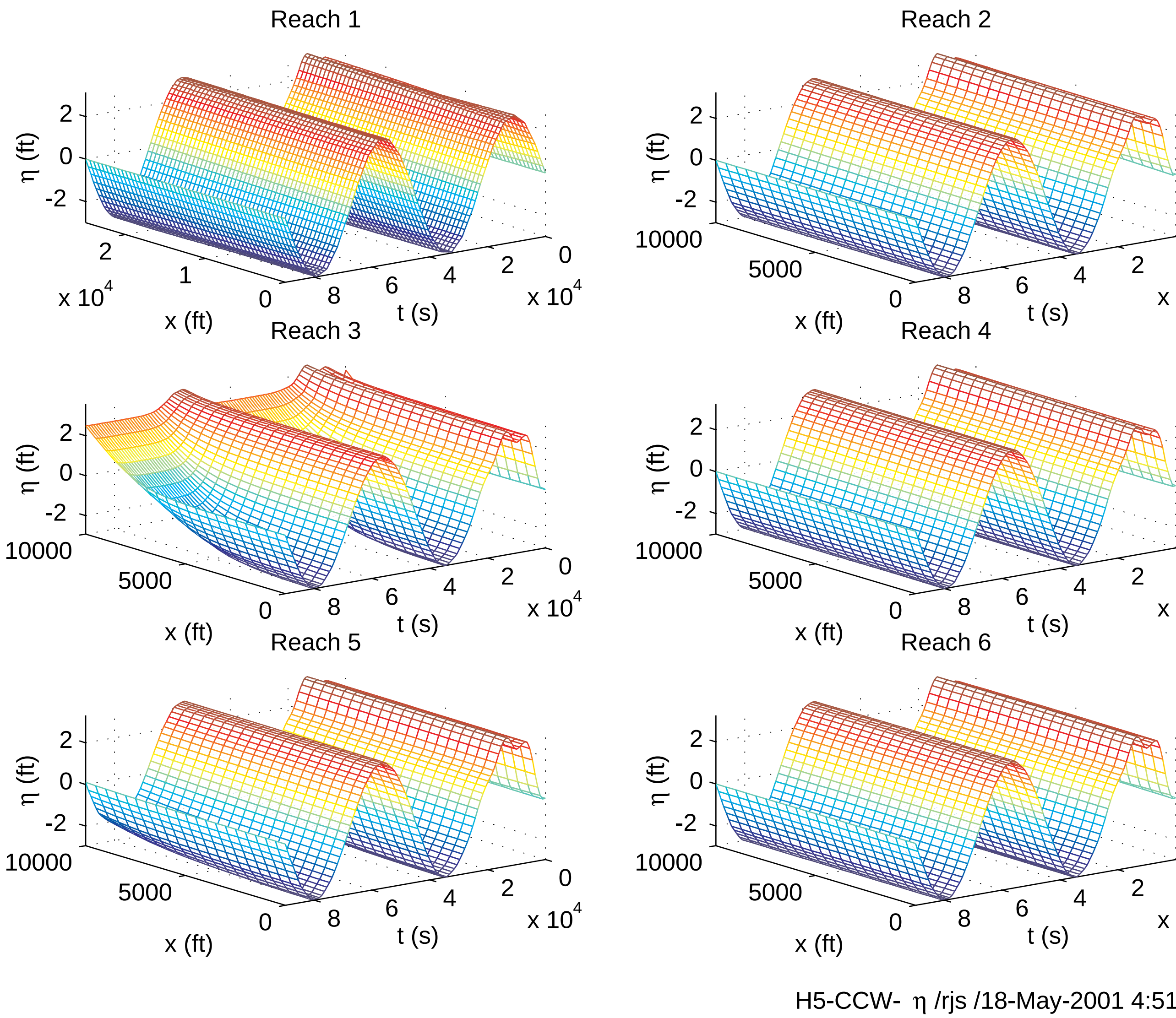

Figure 8.1: H5 CCW-predicted η solution field evolution.

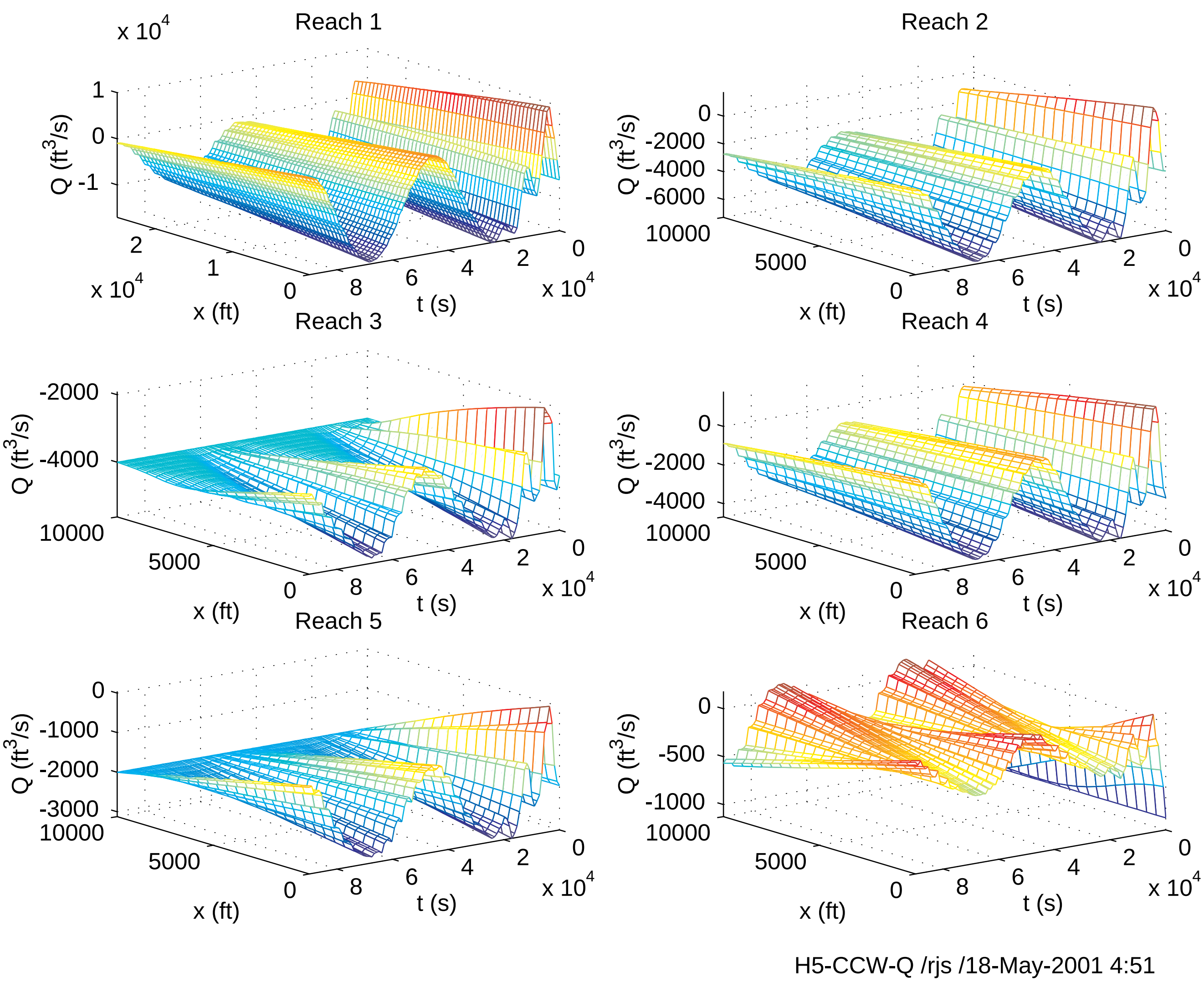

Figure 8.2: H5 CCW-predicted Q solution field evolution.

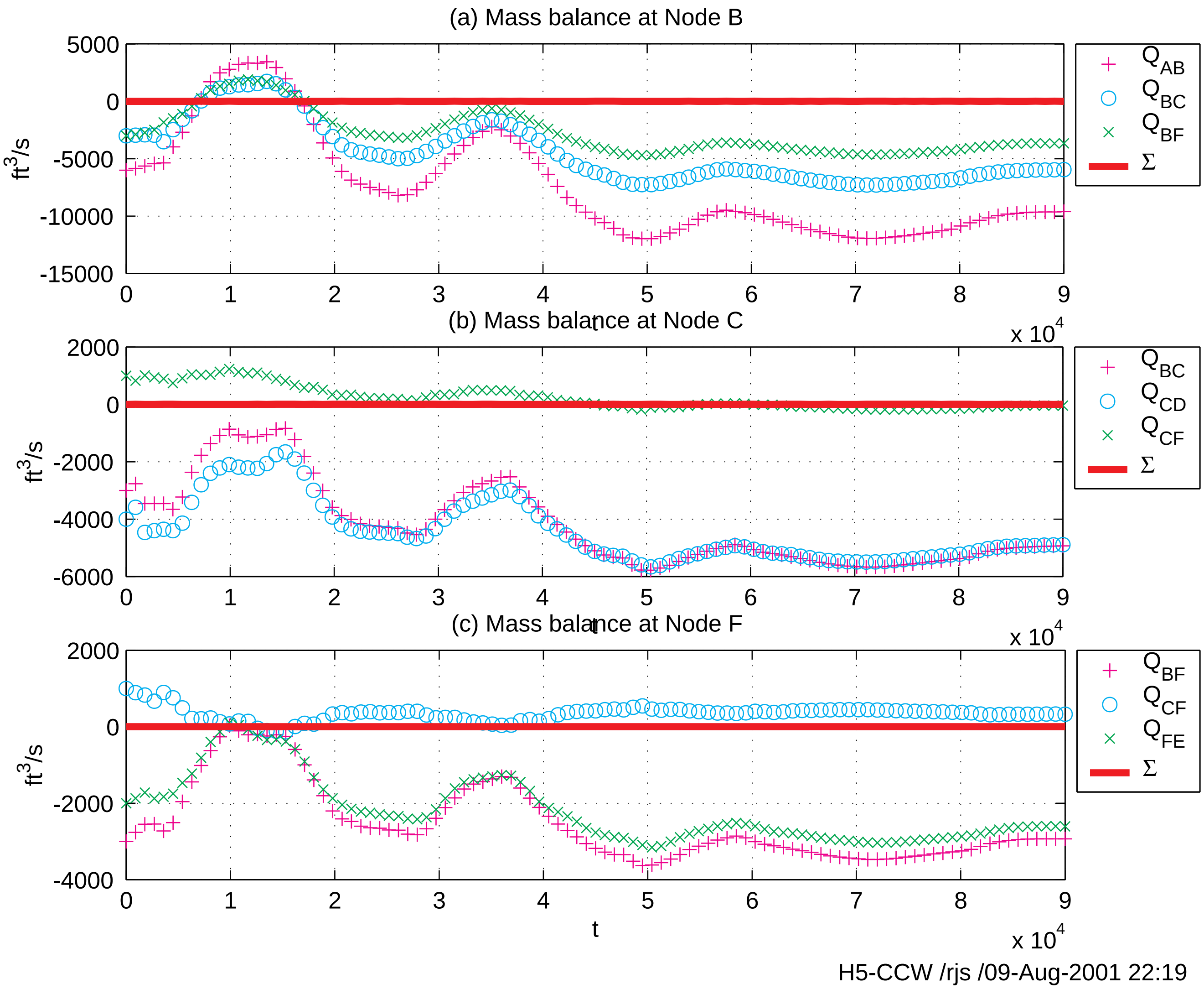

Figure 8.3: H5 CCW-predicted mass balances at network nodes.

8.4 Department of Water Resources

Figures 8.4 and 8.5 shows the DWR-predicted[2] η and Q evolution toward the steady state. These show the anticipated response to tidal forcing, namely oscillatory tidal flow superimposed on the freshwater throughflow. Tidal circulation penetrates into upstream upstream reaches CD (Reach # 3) and EF (Reach # 5). Figure 8.6 shows the instantaneous flow or mass balances at junctions B, C and F. The evolution of these junction flows is expected to reflect the tidal circulation, especially at junction B during the second tidal cycle, at times $T < t \leq 2T$. The "freshwater" throughflow is large, but there are indications of tidal circulation.

[2] Recall the DWR changes to the reach numbering and flow directions described in Section 7.4 and Table 7.3. In addition, the DWR data file reports the computational time step Δt as 1 s; it was apparently not the specified 30 s, but 60 s. The time step has been changed to 60 s for the following analyses.

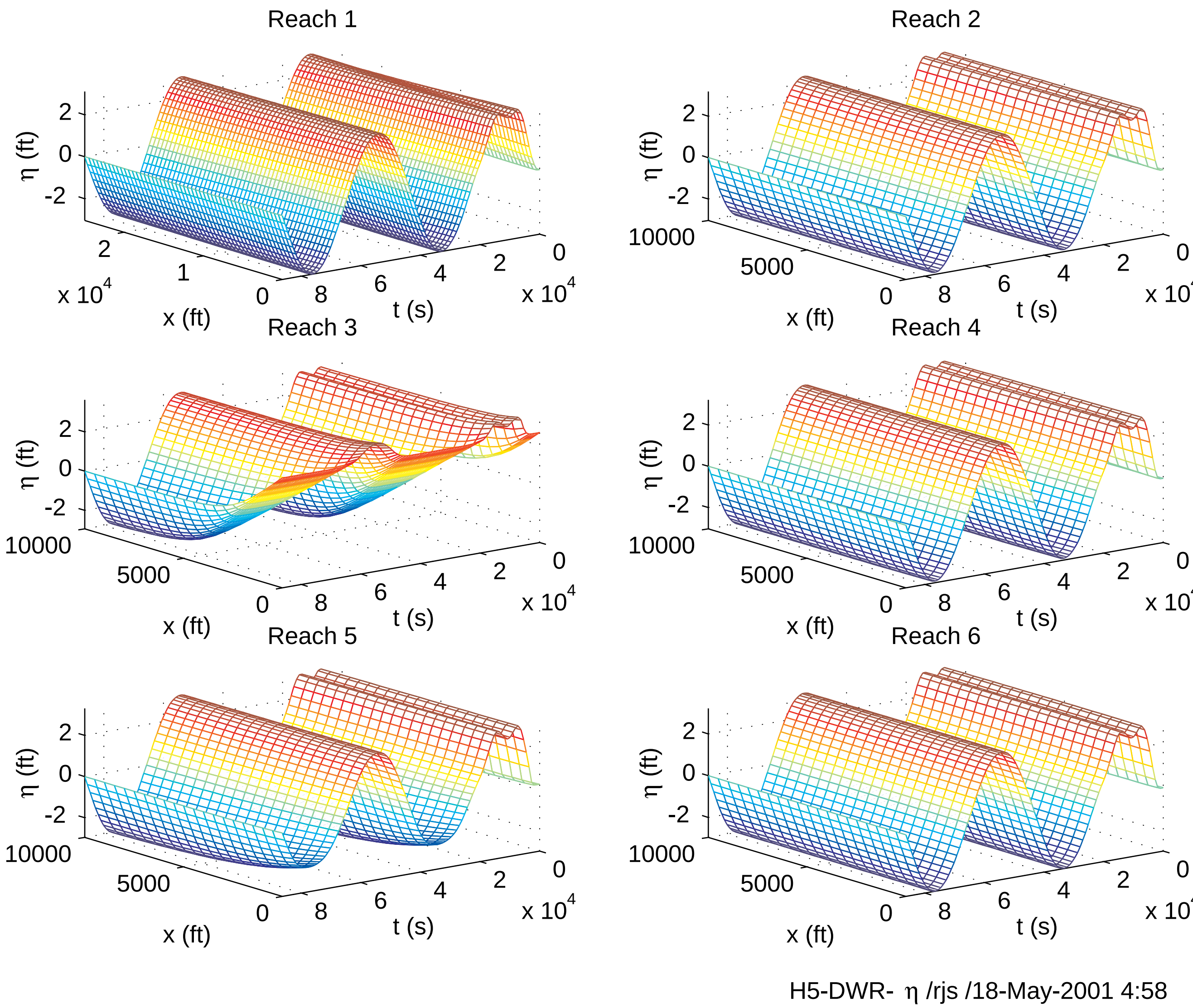

Figure 8.4: H5 DWR-predicted η solution field evolution.

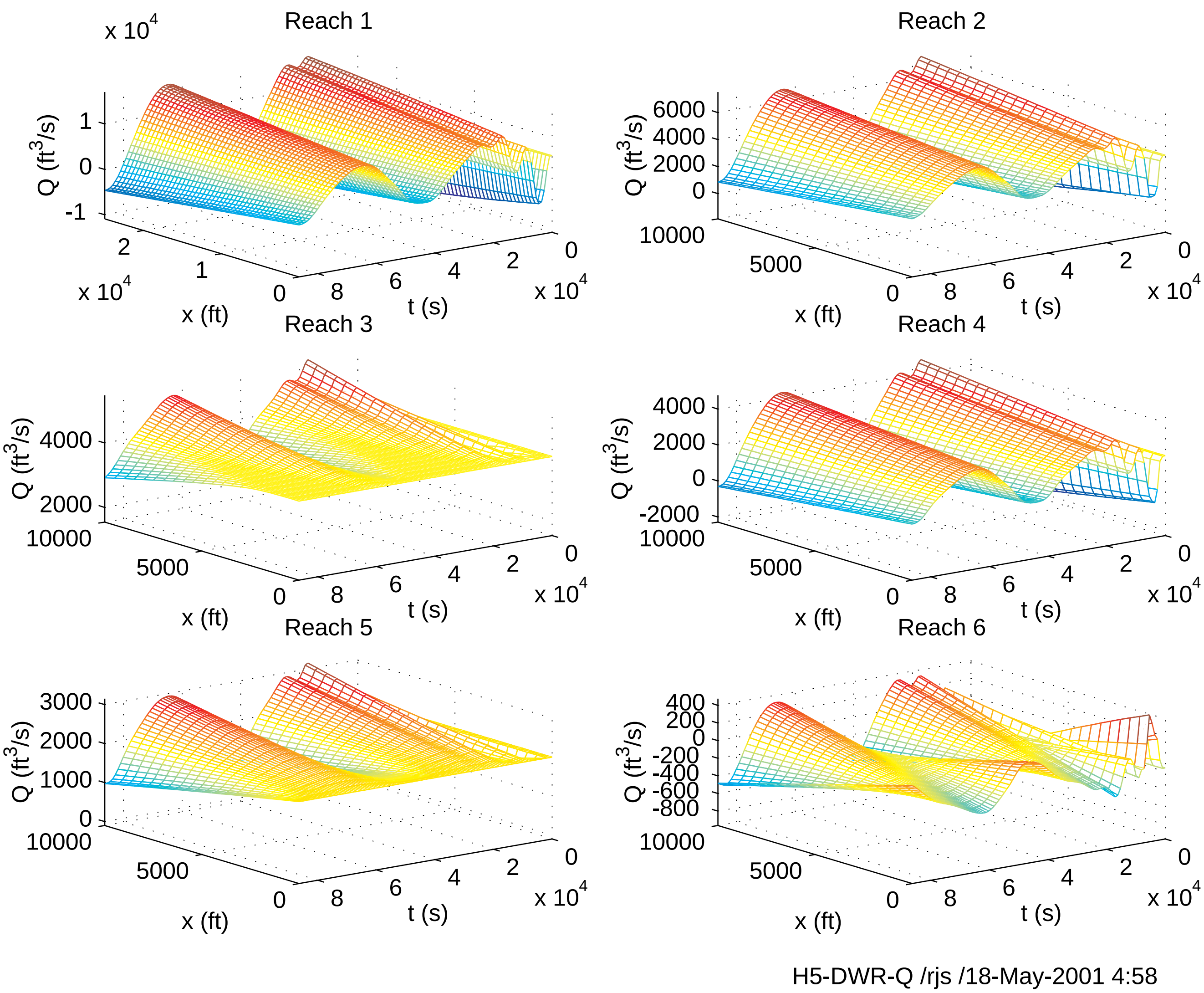

Figure 8.5: H5 DWR-predicted Q solution field evolution.

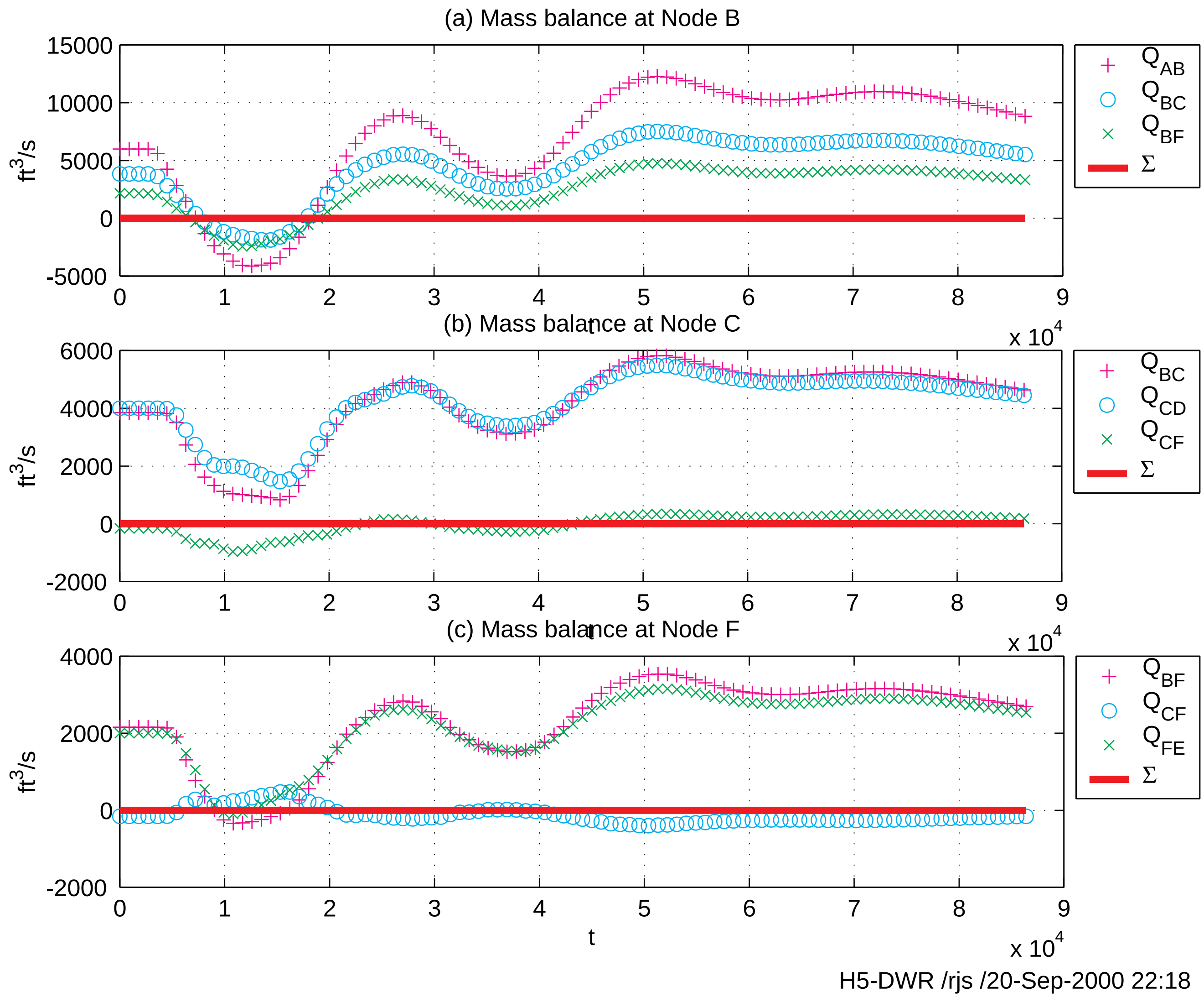

Figure 8.6: H5 DWR-predicted mass balances at network nodes.

8.5 Resource Management Associates

Figures 8.7 and 8.8 shows the RMA-predicted η and Q evolution toward the steady state. These show the anticipated response to tidal forcing, namely oscillatory tidal flow superimposed on the freshwater throughflow. Tidal circulation penetrates into upstream reaches CD (Reach # 3) and EF (Reach # 5). Figure 8.9 shows the instantaneous flow or mass balances at junctions B, C and F. The evolution of these junction flows is expected to reflect the tidal circulation, especially at junction B during the second tidal cycle, at times $T < t \leq 2T$. The "freshwater" throughflow is large, but there are indications of tidal circulation.

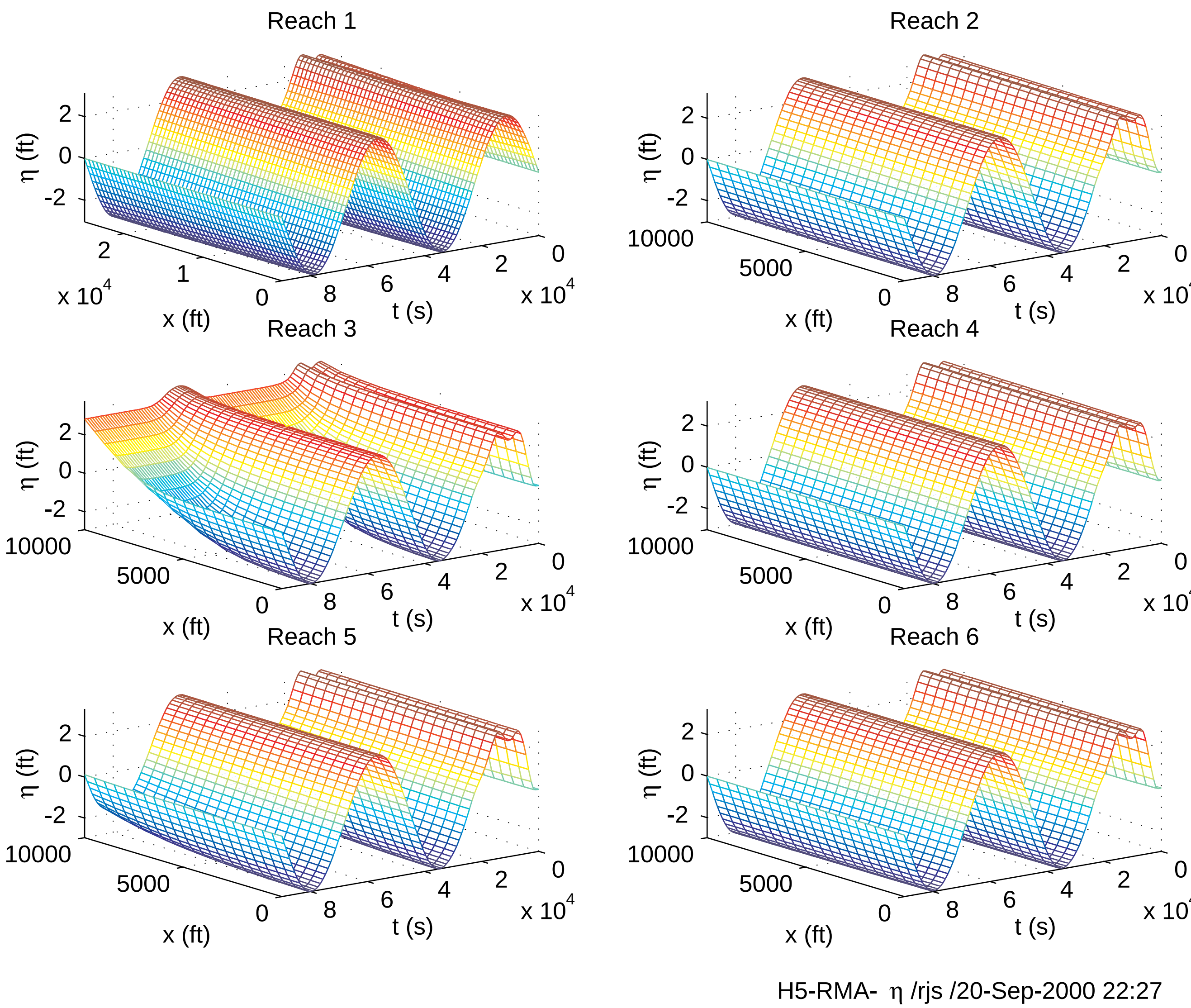

Figure 8.7: H5 RMA-predicted η solution field evolution.

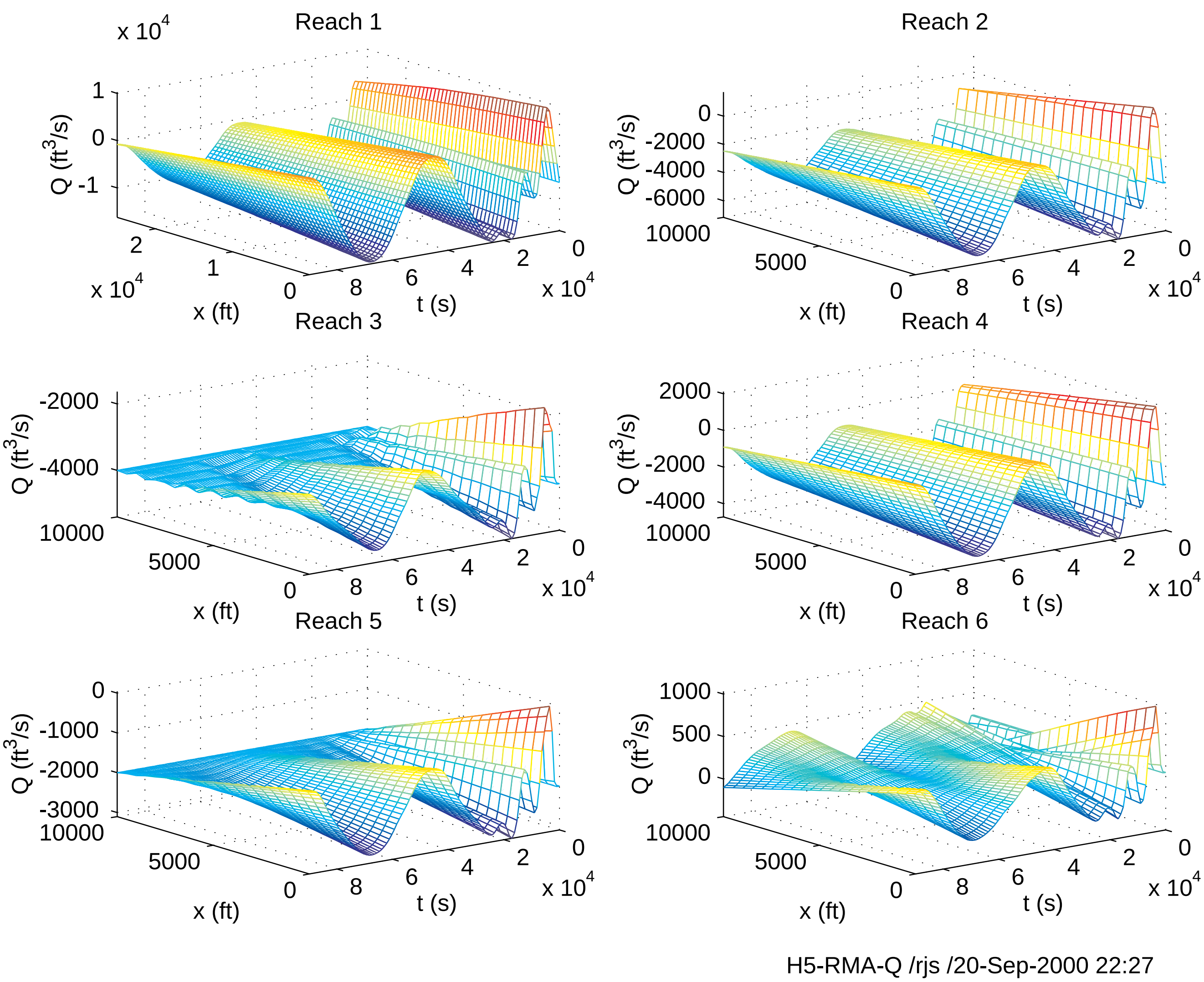

Figure 8.8: H5 RMA-predicted Q solution field evolution.

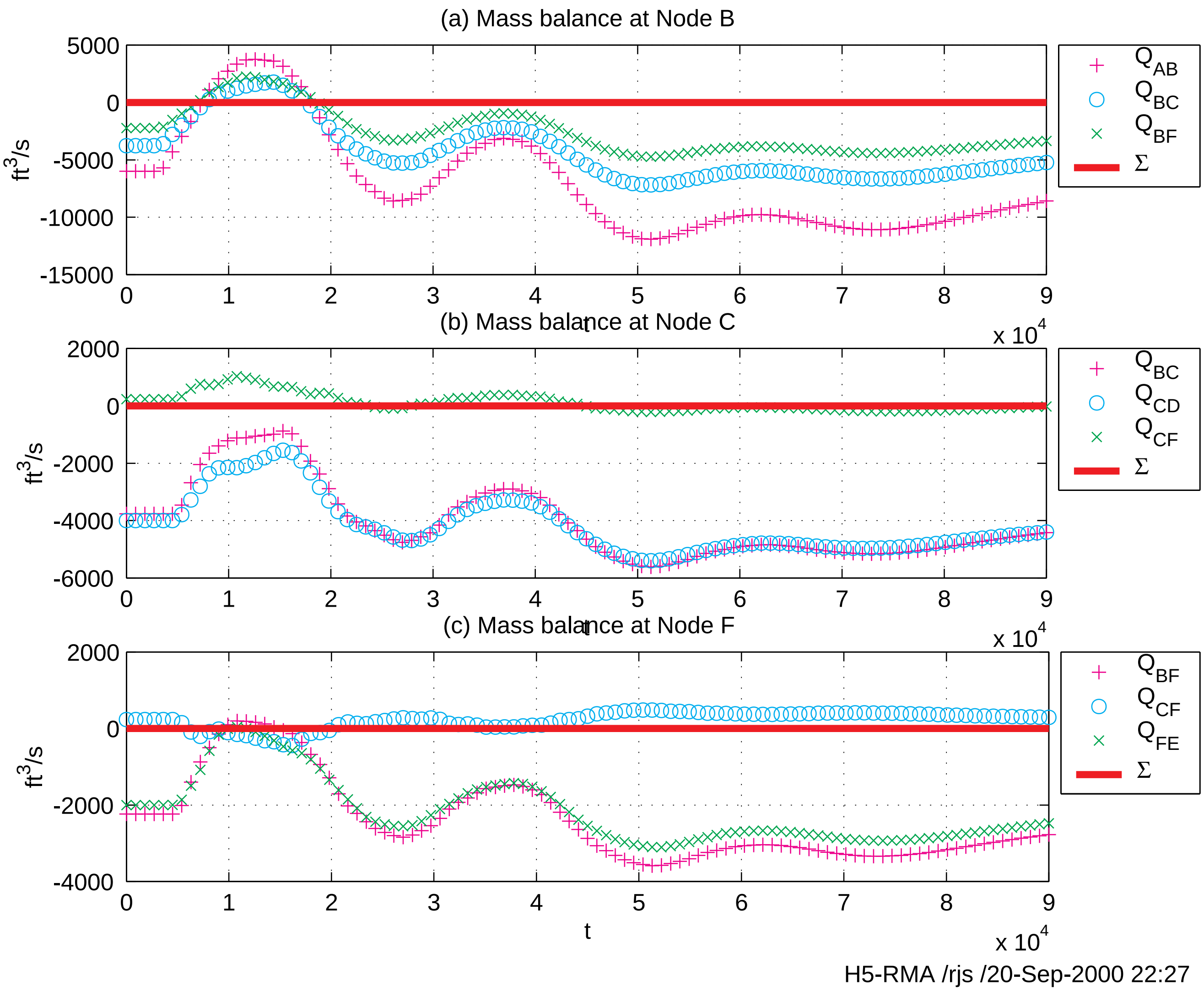

Figure 8.9: H5 RMA-predicted mass balances at network nodes.