# Scenario 10

This scenario considers that the gates are opened for 14 days; then the gates are closed, except the ones at the right side near the diversion (gates a & b in Figure 7 in the manuscript) which remain open for 28 days. Then (gates c and d) are opened for 28 days after closing (gates a and b), thereafter the gates are closed, and the middle gates (b and c) are opened for 28 days, later all gates are opened again for the rest of the time of the simulation.

# Scenario 11

This scenario considers that the gates are opened for 14 days; then the gates are closed, except the one at the right side near the diversion (gate a) which remain open for 28 days. Then (gate b) are opened for 28 days after closing (gate a), thereafter the gate in the middle (gate c) are opened for 28 days after closing (gate b), then (gate d) are opened for 28 days after closing (gate c), later all gates are opened again for the rest of the time of simulation.

# Results:

## **Bed level**

The sedimentation in scenario SGO10 is higher than in the reference case (SGO1) from the beginning of the main canal till 250 m, then erosion occurs and bed levels become lower than bed level in case SGO1 till 1100 m, then a deposition occurs in this area and bed levels become higher than in case SGO1 till upstream the gates. Downstream the gates erosion occurs till the end of the canal, while in case SGO1 there is deposition (Figure S1).

While for scenario SGO11, the sedimentation is the same as in scenario SGO10 till upstream the gates. Downstream the gates the deposition is higher than in the reference case (SGO1) till 250 m, then the deposition will be less till the end of the canal (Figure S1).



**Figure S1** The bed level in scenarios SGO10 and SGO11

In these scenarios, opening Operating only two gates/ one gate from the total number of gates has an actual impact on the sediment transport, flow parameters and the bed of the canal. Figure S1 shows that by using 1D representation, it is hard to tell the difference between the scenarios. While presenting in 2D/3D mode, the difference among these scenarios can be seen (Figures S2 and S3) as well as the position of erosion and accumulation of sediments.



**Figure S2** The bed level within different cross-sections in scenarios SGO10 and SGO11

The velocity has a major impact on the sediment deposition and erosion patterns along the vicinity of the gate structure in the canal, as discussed previously and shown in Figure 9 in the manuscript.



**Figure *S3*** Cumulative erosion/sedimentation by multiple operating of gates compared to the reference case

From Figure S3, it is noticed that multiple operation of two gate at the same time (Scenario 10) has more erosion downstream the gates in the main canal than multiple operation of gate, while in the branch canal a higher deposition occurs.

## Other parameters

### Water level

An important indicator in an irrigation system is the water level because it determines the amount of water diverted to the offtakes and fields. The scenarios with two gates closed have similar water level with small differences, but all are higher than the water level in the reference case along the main canal till upstream the gate. Downstream the gates, the water level became lower than in the reference case.

Likewise, the scenarios with one gate closed exhibit a similar water level, which is higher upstream gates compared to the water level in the reference case and also higher than in scenarios with two gates open. The higher water level tends to create a pool effect with decreased velocity and accumulation of water to accommodate the flow into the branch canal. Downstream of the gate the water level is lower than in the reference case (Figure S4).



**Figure S4 Water level along longitudinal mid-section of the main canal for different scenarios.**

In Scenario 10, water level upstream the diversion is little bit lower than in Scenario 11 till 600 m thereafter water level became equal, while at 900 m till the end of main canal as shown in Figure S5.



**Figure S5** Water level along the main canal in scenarios SGO10 and SGO11

### Velocity

For scenario SGO1 the velocity transitions smoothly along the main canal, while within the cross-section the velocity in the middle is higher than the velocity in both sides (Figure S6). When the gates are closed, the velocity upstream of the gate decreases, while at the gate and after the gate, velocity increases. In scenarios SGO2 and SGO4 the velocity is high in the side close to the diversion but differs in magnitude. In scenario SGO3, the velocity is high in the side far from the diversion. In scenario SGO5 the higher velocity is in the middle of the main canal.



**Figure S6** Depth-averaged velocity for scenarios with two gates opened

From Figure S6 an eddy can be seen downstream the gates for scenarios SGO2 and SGO3 at the side far from the diversion due to the disturbance caused by opening only two gates. In scenario SGO4, eddies are found at the side close to the diversion.

Opening one gate leads to less velocity upstream of the gates as compared to the velocity in the reference case. At the location and directly below the opened gate, velocity increases. Thereafter until downstream the main canal, the velocity is less than in the reference case. In scenarios SGO6 and SGO7, the velocity is high at the side close to the diversion but differs in magnitude. In scenario SGO8 and SGO9, the velocity is high at the side far from the diversion (Figure S7).



**Figure S7** Depth-averaged velocity for scenarios with one gate opened

From Figure S7, an eddy can be seen downstream the gates for scenarios SGO6 and SGO7 at the side far from the diversion due to the disturbance caused by opening only one gate. In scenario SGO8 and SGO9, eddies are found at the side close to the diversion. Opening two gates induces less velocity than the velocity in the reference case but higher than the velocity in scenarios with one gate open. The velocity is comparably lower at the sides of the canal and fairly minimal behind the closed gates. Based on Figures S6 and S7, these are the expected areas where the sediment deposition can occur due to the reduction in velocity, which confirms what we had seen in Figures 12 and 15 in the manuscript.

The velocity in these scenarios has a different pattern from the one in the reference case (SGO1), wherein SGO1 the velocity has a smooth transition between the upstream and downstream the diversion, velocity has a small increase in the gates area. While in both scenarios (SGO10, SGO11) velocity is higher in than in reference case. In SC11, a higher velocity than in case SC10 at the gates area occurs (Figure S8). This higher velocity leads to higher transport capacity leading to convey more sediments as shown in Figure S11.



**Figure S8** Velocity patterns in the system with different scenarios SGO10 and SGO11

### Sediment transport

In scenario SGO1, the sediment transport in the main canal upstream and downstream of the gates is almost similar, because of the slight change in the velocity. Unlike in other scenarios, the total sediment that is moved towards upstream of the gate is quite different from that at the downstream of the gate. The sediments in the upstream part are moved in the middle at a higher rate than on both sides. The transport at the downstream is also affected by velocity: sediments move where velocity is sufficient to convey them. Because the distribution of velocity within the cross-section is disrupted by the closure of the gates, the sediments being transported also change and are distributed unevenly within the cross-section. In the scenarios with one and two gates opened, the reduced velocity upstream the gates leads to reduced sediment transport capacity and high bedload; most of the bed load settles, which leads to having a more total load (Figure S9). Downstream of the gate the increased flow velocity, due to the constriction of the gate closure, leads to an increased transport rate, increased erosion and reduced bed and total load.



**Figure S9** total load transport in the main canal for different scenarios with two gates opened.

The accumulated sediments downstream of the gate on both sides of the canal are higher than in the upstream of the gate. This means when the sediment transport rate is high due to high velocity, less sediment deposition will occur and vice versa. Moreover, the sediment transport in the canal is dominated by a suspended load over bedload. The sill height of the gate blocks the bed load to transport further downstream. So, suspended sediments often flow towards downstream of the gate and the bedload tends to settle at upstream of the offtake.

There is a difference between the volume of outgoing sediments from the branch canal and the incoming sediment from the main canal into the branch canal. This means that the difference has been settled in the branch canal. The percentage of sediment eroded/deposited is calculated and presented in Table 5. However, any local erosion/sedimentation within these cross-sections cannot be adequately captured in this calculation due to the coarse resolution of the modelling.

In scenarios with one gate opened, the reduced velocity upstream of the gates lead to reduced sediment transport capacity and high bedload, leading to high total load; most of the bed load settles (Figure S10). While downstream the gate, there is no bedload because of the high transport rate due to the high velocity. Thereafter there is low bedload and low total load until the end of the main canal. The bedload in cases with two gates opened is less than the bedload in cases with one gate opened, because the transport rate is high due to the higher velocity.



**Figure S10** Total load transport in the main canal for different scenarios with one gate opened.

Both scenarios have a higher sediment transport than the reference case (Figure S11) due to the high velocity. In Scenario 11 the total transport is higher than in Scenario 10.



**Figure S11** Total sediment transport in the system with different scenarios SGO10 and SGO11