GROUNDWATER ASPECTS OF INTER-BASIN WATER TRANSFER

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ABSTRACT *Various implications of the inter-basin water transfer in respect of the groundwater systems of the donor and the receiving basins are discussed. Unless groundwater withdrawal patterns in the donor and the receiving basins are appropriately modified, the inter-basin transfer shall disturb the dynamic equilibrium of groundwater system of the basins. The socio-economic-environmental-technical implications of such modification in the withdrawal pattern can be quantified by groundwater modeling. These must be considered while determining the feasibility of a trial inter-basin transfer pattern.*

Key words Groundwater systems; dynamic equilibrium; inter-basin water transfer; stream aquifer interaction; groundwater modeling.

INTRODUCTION

Inter-basin water transfer shall trigger off a variety of hydrologic processes which in turn shall disturb the current hydrologic cycles of the donor and the receiving basins. New hydrologic cycles, characterized possibly by markedly different attributes, shall be established at the end of the transition period. The new attributes are bound to have significant implications in respect of the surface water and groundwater systems of the donor and the receiving basins. The implications in respect of the groundwater system are discussed in the following paragraphs.

DONOR BASIN

The impact of the water transfer on the groundwater system of the donor basin would basically arise from changes in the stream aquifer interaction.

Modified Stream Aquifer Interaction

The transfer of water from the donor basin shall essentially cause a decline in the river stage downstream of the transfer section. The immediate consequence of this decline shall be a modification in the interflow between the river and the hydraulically connected aquifer. If the aquifer has been receiving lateral recharge from the river, there shall be a reduction in that. On the other hand if the aquifer has been contributing flow to the river, there shall be an increase in it.

This modification in the stream aquifer interaction would lead to an increased 'loss' from the recharge. There are two possible implications of this increase. First, if the current (i.e., pre-transfer) dynamic equilibrium of the groundwater system is to be sustained, the increase in the loss must be accounted for while estimating the groundwater resource. This would inevitably lead to a reduction in the resource, requiring attenuation of withdrawals and/or artificial recharge. Second implication relates to sustenance of the pre-transfer withdrawals/recharge. This would alter the dynamic equilibrium of the groundwater system, as described below.

New Dynamic Equilibrium

Assuming that the withdrawal and vertical recharge patterns of the aquifer remain unaltered, the modification in the stream aquifer interaction shall trigger off a falling trend of the water table. The trend is going to sustain until a new dynamic equilibrium is established. The new equilibrium shall be characterized by (i) near-restoration of the original stream-aquifer interaction and (ii) lower water table elevations.

The *adverse consequences* of realization of the new dynamic equilibrium in the donor basin include the following:

Socio-economic consequences The fall in the water table could lead to drying up of the shallow wells in the area. Further, the discharge for the same pumping-units shall decrease or pumps of larger power shall be required to maintain the original discharge. Accordingly the cost of pumping a unit volume of groundwater shall increase.

Attenuation of drought mitigation Perhaps the most alarming consequence of the water table lowering is the associated reduction of the static storage of groundwater in the aquifer. This reduction has a direct bearing on the capacity of the aquifer to mitigate droughts. Thus, one major advantage of groundwater development is lost or attenuated.

Enhanced sea water intrusion In case of coastal aquifers, this could be another major adverse consequence of the water table decline. Decline of the water table shall lead to reduction in the outflow to sea and hence the enhancement of the sea water intrusion. In fact as per Ghyben-Herzberg's approximation, every centimeter decline of the water table shall lead to rise of the saltwater interface by 40 cm.

A few *favourable consequences* realized during the transition and new-equilibrium stages are as follows:

Attenuation of water logging As already mentioned, the new dynamic equilibrium would be characterized by lower water table elevations. If the land of the donor basin happens to be water logged, the lowering may attenuate/eliminate the water logging.

Improvement of groundwater quality Consider a situation wherein the water table elevation is initially lower than the river stage. The resulting influent seepage from the river into the aquifer may be deteriorating the groundwater quality on account of possibly poor river water quality.

As the inter-basin transfer occurs, the river stage falls and this may temporarily reduce or may even eliminate the influent seepage into the aquifer. This may lead to some improvement in the quality of groundwater. However, this benefit would be temporary since, the fall of river stage would be followed by fall of the water table, which would attenuate the benefit. As already mentioned the pre-transfer stream-aquifer interaction would be restored at the new dynamic equilibrium. Thus, this benefit would be completely lost once the new dynamic equilibrium comprising lower water table elevations is reached, and the pre-transfer influent behaviour of the stream is restored.

RECEIVING BASIN

The impact of the water transfer on the aquifers of the receiving basin would be almost reverse of the impact in respect of the donor basin. Thus, the transfer shall essentially cause a rise in the river stage downstream of the water entry section leading to a modification in the interflow between the river and the hydraulically connected aquifer. If the aquifer has been receiving lateral recharge from the river, there shall be an increase in that. On the other hand if the aquifer has been contributing flow to the river, there shall be a reduction in it. This shall increase the groundwater resource in respect of the current (i.e., pre-transfer) dynamic equilibrium. However, if the withdrawals are not enhanced, the increased influent seepage shall trigger off a rising trend of the water table, which is going to sustain until a new dynamic equilibrium is established. The new equilibrium shall nearly restore the original stream-aquifer interaction at higher water table elevations.

The consequences of realization of the new dynamic equilibrium in the receiving basin shall be reverse of consequences in respect of the donor basin. Thus, they shall largely be *favourable*. The rise in the water table could lead to revival of dried-up wells apart from reducing the unit cost of pumping groundwater. The increased static storage would improve the drought mitigation potential of the groundwater aquifers. The raised water table elevation in coastal aquifers would lead to reduction in sea-water intrusion. The *adverse* consequence could be an increase in water logging. Further, the influent seepage during the transition stage may increase the influent seepage leading to possible deterioration of the groundwater quality.

FEASIBILITY CHECK

It is apparent from the preceding discussion that the feasibility of any proposed inter-basin water transfer would be determined by amongst others, the impact of the trial transfer pattern on the groundwater systems of the donor and the receiving basins. The feasibility check in respect of the groundwater systems would require quantification of various consequences described earlier. If the consequences are found to be too severe to be acceptable, a downsizing of the transfer pattern may be necessary.

Role of Groundwater Modeling

The scenarios corresponding to the transition as well as the new dynamic equilibrium in the donor and the receiving basins can be projected by groundwater modeling. Such projections can provide the necessary quantification of the consequences of the proposed transfer in respect of the groundwater systems of donor and receiving basins.

CONCLUSION

Unless groundwater withdrawal patterns in the donor and the receiving basins are appropriately modified, the inter-basin transfer shall disturb the dynamic equilibrium of groundwater system of the basins. The new dynamic equilibriums in the donor and the receiving basins shall be characterized by lowered and raised water table elevations, respectively. The socio-economic-environmental-technical implications of such modification can be quantified by groundwater modeling. These must be considered while determining the feasibility of a trial inter-basin transfer pattern.