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Investigation of Optimal use of Canal Water in Pakistan

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Abstract

This research work was executed to evaluate hydraulic performance of an irrigation system in Pakistan. Repetitive testing of influence of a wide variety of design parameters and hydraulic assumptions was made. The one-dimensional hydrodynamic model CANALMAN was applied to real data from Shingrai Minor of Upper Swat Canal irrigation system in NWFP Pakistan to study its hydraulic performance. Extensive field data was collected to evaluate the physical & hydraulic parameters needed to calibrate the model. Effect of changes in roughness values (Manning's constant) was investigated. The system performance was tested for various discharges to find out the best alternative. It was observed that appreciable amount of water could be saved using alternatives recommended in this paper.

Introduction

Pakistan has one of the world's largest system of irrigation. It has about 60000 km of total length of canals with a drawls of nearly 106 million acre feet per annum. Total length of water courses is 1600000 km. Overall losses in the system are very high. However, water being a highly valuable commodity, needs strategies for its optimal use. There is a great need for efficient operation and management of irrigation system. This paper deals with the use of hydrodynamic model to assess first of all the hydraulic behavior of the canal and hence to investigate the optimal discharge values apply it. Several hydraulic simulation models like MIKE-II, Canalman, SIC and RBMC are now available.

Waijen et al (1997) used hydrodynamic flow model SIC (Simulation of Irrigation Canals) to evaluate the impact of alternative maintenance measures. Kuper et al. (1997) analyzed the impact of operational rules on the water distribution using SIC. Habib et al. (1998) used Canalman to check the consultant's design of a crop-based system. Godaliyadda et al (1999) studied improvements to normal operational procedures for the main types of irrigation systems identified in Sri Lanka. Mishra et al (2001) evaluated the MIKE II hydraulic model. To study improvements in the operation and management of the main canal system through performance assessment. Bievre et al (2003) studied the effect of reduction in night irrigation in medium sized irrigation schemes using MIKE II hydraulic model.

The previous modeling studies have focused on the traditional supply based systems, or are limited to the evaluation of the design of the systems only. Limited work has so far been done on optimal use of water in Pakistan. This paper deals with this task. The canal management model CANALMAN, developed by the Utah State University, USA, was applied to Shingrai Minor of Upper Swat Canal irrigation system in NWFP Pakistan.

Location & Extent

Shingrai Minor was selected for this research project. This takes off from left side of Abazai branch at RD 12599 m (41325 ft) near Palonow, Hero Shah, Malakand Agency and end at Shingrai village The total length of minor is 5309m (17413 ft) with design discharge of 832.12 L/Sec (0.83 Cumecs). It has two outlets and 11 Bifurcator. The total C.C.A of the minor is 1169.6 ha (2924 acres).

Collection Of Data

Detailed data of the Shingrai Minor in the form of design longitudinal profiles, cross sections of the canal, and the design of the outlets was collected from WAPDA (SCARP), Sawabi. Daily water levels records over a period of six months at the intake of the minor and the at most of the outlets of the canal were also taken. The outlets and the intake of the canal were calibrated.

The Simulation Model:

Canalman (see Merkley G.P. 1997) is a *Canal Management Software*. *Canalman* implicitly solves an integrated form of the Saint-Venant equations: continuity and motion (Strelkoff 1969) for one-dimensional unsteady open-channel flow. This simulates water levels and discharge at required places along the reach.

Computational nodes are used internally by the model, and they are automatically inserted along the length of a canal reach, between the system layout nodes.

System Layout

The system layout window shows a schematic plan view of the canal system as shown in figure 1. The nodes in the plan view correspond to the system source, downstream ends of canal reaches, and bifurcation points.

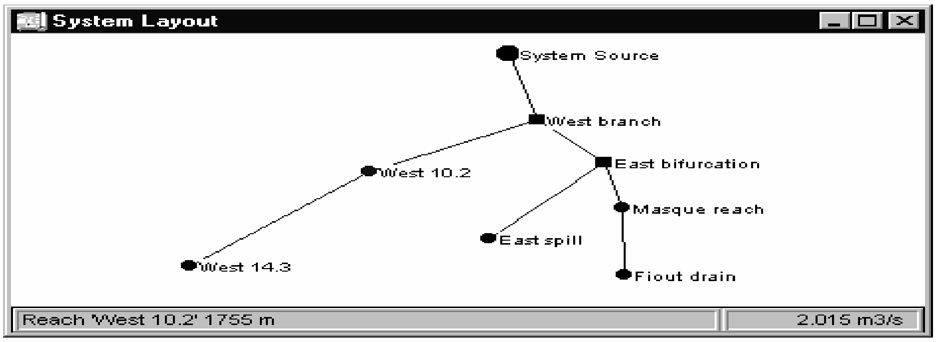


Figure-1: System layout

Configuration of Flow Control Structure

Total length selected for simulation was divided into six reaches. Base width was selected to be representative of practical values in real channel. In reach 1 to 4, old, broken and rough concrete lining exists, so, 0.0173 was taken as Manning's roughness. In reaches 2-6, new and smooth concrete lining has been provided; so, 0.0113 & 0.0108 were used.

Simulation Scenario/ Case Studies:

Three case studies to present more practical cases of operations, were taken.

Case –I Simulated Design Discharge with 100% outflow through outlets.

Case –II Manning's n values were changed by ±1, ±2 and ±3% for all reaches.

Case –III Simulation with different discharge values.

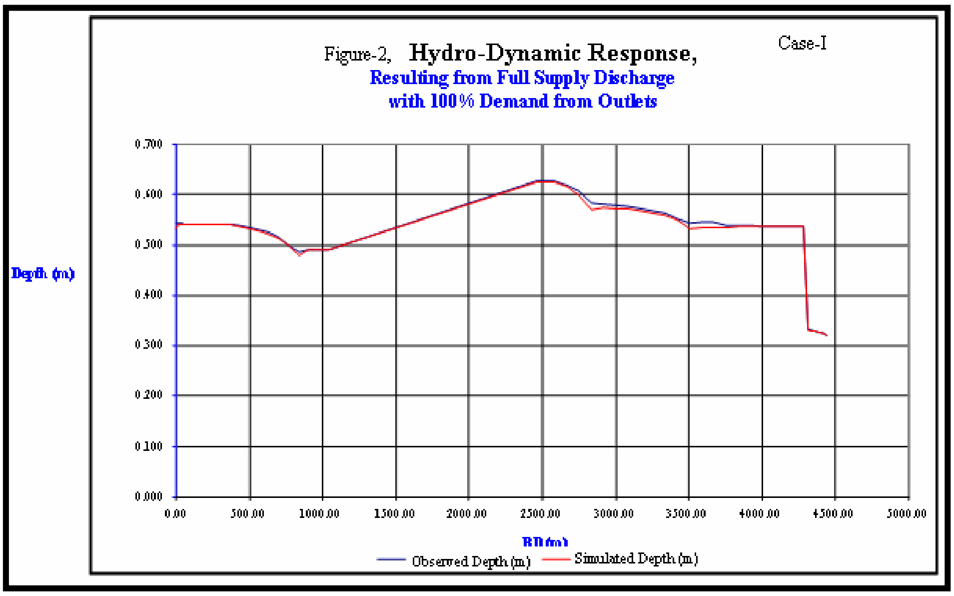
Results And Discussions

The results of cases-I to III are shown in figures 2 to 6. The results of case I show that simulated values are almost identical to observed values and few with small perturbation (i.e. 0.898%) falls within tolerance range.

Discharges become essentially constant after 3:23 hrs of simulation period which indicate that flow conditions are quite stable. Inline flow control structures provide smooth operation. Offtaking structures draw their allocated share of water. However flow rate at tail is 32.05% greater than its designed discharge.

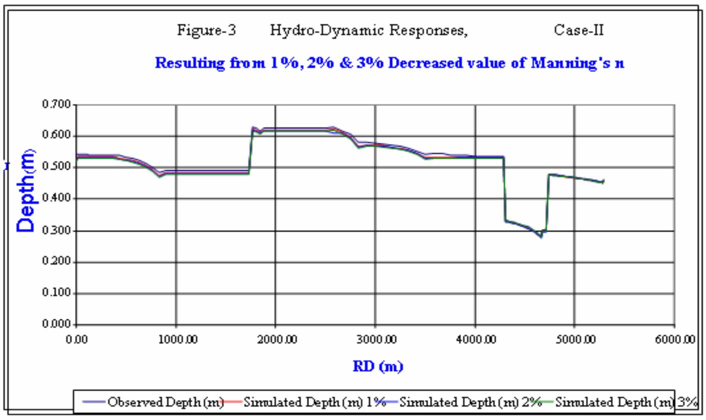
In Case-II, Hydro-Dynamic responses for operating simulation system with ±3% values of Manning's 'n' represents a relation between depths (Observed & Simulated) & reduced distances (RD) of complete channel. On comparing these results it is found that when the Manning's roughness is increased by 1% in all reaches, simulated water level raises 0.42cm. with respect to case-I. Similarly, for 2% increase it is 0.67cm and for 3% increase it becomes 1.02cm which would be expected. The increase observed stand within design limits & no over flow happen in any reach. Flow velocity comparatively decreased. Flow conditions remains stable & flow control structures show a stable operation. Simulation took 17.85% greater time with respect to Case-I.

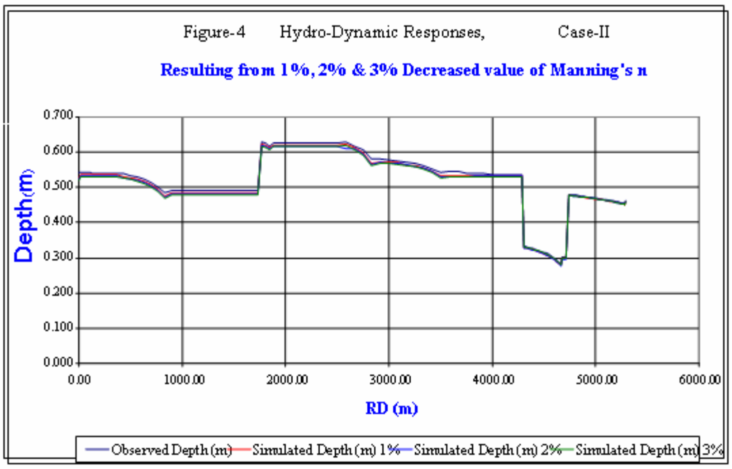
In contrast, in Figure-2 on decreasing 3% roughness value in uniform increments we find 0.31cm, 0.55cm & 0.65cm falls in the simulated water levers which would also be expected. Flow velocity is increased. Simulation took 1.57% less time with respect to Case-I to gain stability. Offtaking structures also retained their allocated share of water.



In Case-III, Figure-3 highlights the Hydro-Dynamic responses resulting from 3% increased supply of inflow from Head Regulator in three uniform increments.

Figure-4 show hydraulic response when supply released from system source is less than full supply by 1%, 2% & 3%. The simulated results are compared with observed where, a decrease of 0.532cm, 0.533 & 1.56cm in all the reaches noted respectively. The decrease in simulated depth did not create any adverse effect on stability of flow condition. Discharge remains constant. Offtaking structure retained their proportional flow rate; however simulation took 36.23% less time in reaching off stability of low. Optimum value of discharge was found to be .781cumes.





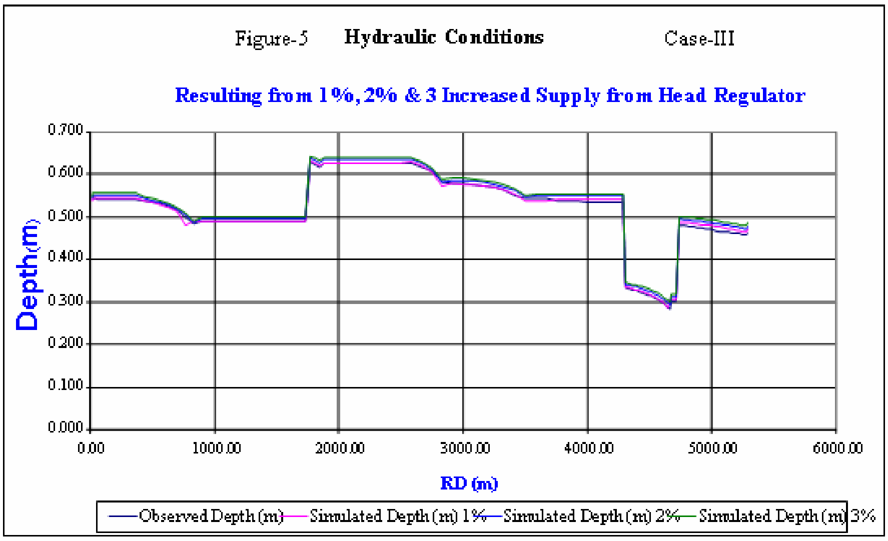


Figure-5 Hydraulic Conditions Case-III
Resulting from 1%, 2% & 3 Increased Supply from Head Regulator
Depth (m)
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.00
1000.00
2000.00
3000.00
4000.00
5000.00
6000.00
RD (m)
Observed Depth (m)
Simulated Depth (m) 1%
Simulated Depth (m) 2%
Simulated Depth (m) 3%

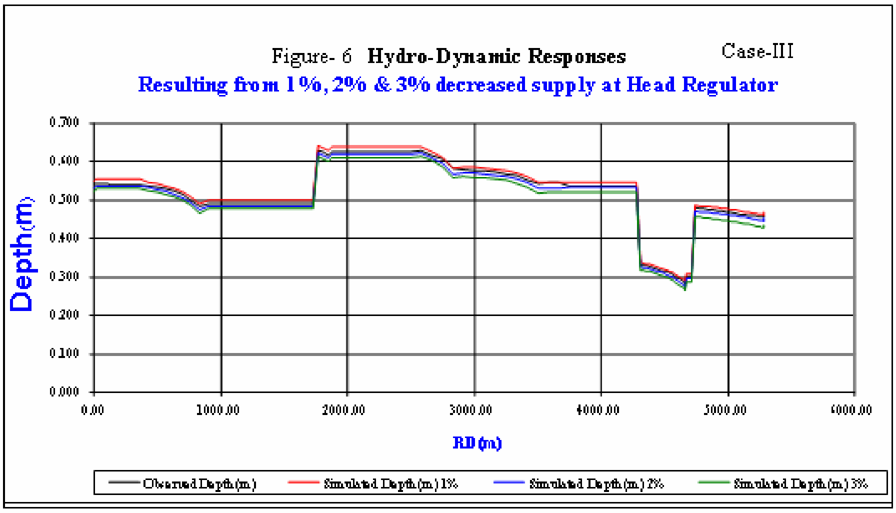


Figure- 6 Hydro-Dynamic Responses Case-III
Resulting from 1%, 2% & 3% decreased supply at Head Regulator
Depth (m)
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.00
1000.00
2000.00
3000.00
4000.00
5000.00
6000.00
RD (m)
Observed Depth (m)
Simulated Depth (m) 1%
Simulated Depth (m) 2%
Simulated Depth (m) 3%

Conclusion

- Hydrodynamic model “CanalMan” used to evaluate hydraulic behaviour is a useful and effective research tool.
- Water level changes can be used as guide line to select desired rate of water release from system source, for given channel depth.
- The performance of canal reaches and regulating structures is meeting the designed objectives.
- In view of present sanctioned demand against specified C.C.A held on charge of Shingrai Minor, its optimal discharge to be 0.781Cumecs which is about 6% less than the design value.

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