플랫강 유역의 위험에 처한 서식지 보호를 위한 MODSIM 하천 네트워크 흐름모의

MOSIM NETWORK FLOW MODELING FOR IMPROVING CRITICAL HABITAT IN PLATTE RIVER BASIN

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Abstract

Like other major river basin systems in the West of the United States the Platte River Basin are faced with the challenges of allocating more water for plant and animal species. A part of the Central Platte River was designated as critical habitat for the whooping crane in 1978. The water allocation system in the Platte River Basin is dominated by the Prior Appropriation Doctrine, which allocates water according to the priorities based on the date of water use. The Platte River Basin segregated into five subregions for purpose of analysis. 24 years of historic records of monthly flow and all the demands were complied. The simulation of river basin modeling includes physical operation of the system including water allocation by water rights and interstate compact agreements, reservoir operations, and diversion with consumptive use and return flow. MODSIM, a generalized river basin network model, was used for estimating the timing and magnitude of impacts on river flows and diversions associated with water transfers from each region. A total of 20 alternatives were considered, covering transfers from each of the five regions of basin with several options. The result shows that the timing and availability of augmented water at the critical habitat is not only a function of use by junior appropriators, but also of river losses, and timing of return flows.

Key words: **Critical Habitat, Network Flow Modelling, MODSIM, Instream Flow, Water Right, Endangered Species, Threatened Species, Water Allocation, Network Model, Conjunctive Use, SDF(Stream Depletion Factor), Prior Appropriation Doctrine**

1. Introduction

As populations expand and economies develop, competition for limited available water resources and conflict between different water uses is intensifying. As with most other major river basin systems in the western United States, water management in the Platte River basin is challenged by the need to comply with the Endangered Species Act of 1973 without harming traditional water uses in the basin. The 90,000 sq. mi. drainage area of the Platte River basin, contained in the three state region of Colorado, Wyoming, and Nebraska, provides habitat for the whooping crane, interior least tern and pallid surgeon endangered species, as well as the piping plover listed as threatened (Figure 1). Although the Central Platte River in Nebraska was specifically designated as critical habitat for the whooping crane in 1978, water management in the entire river basin is impacted by the need to augment streamflows for protection and restoration of these species. Since

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agriculture is currently the dominant water use in the Platte River basin, the economy of the entire region could be greatly impacted by water use restrictions in order to enhance ecological purposes. Complex legal and political issues arise when considering that the legal structure governing water use in the three state region is dominated by the Prior Appropriate Doctrine which establishes priorities based on the earliest dates of diversion of flows for beneficial uses. Interstate compacts and other regulations further complicate water resources management in the Platte River basin.

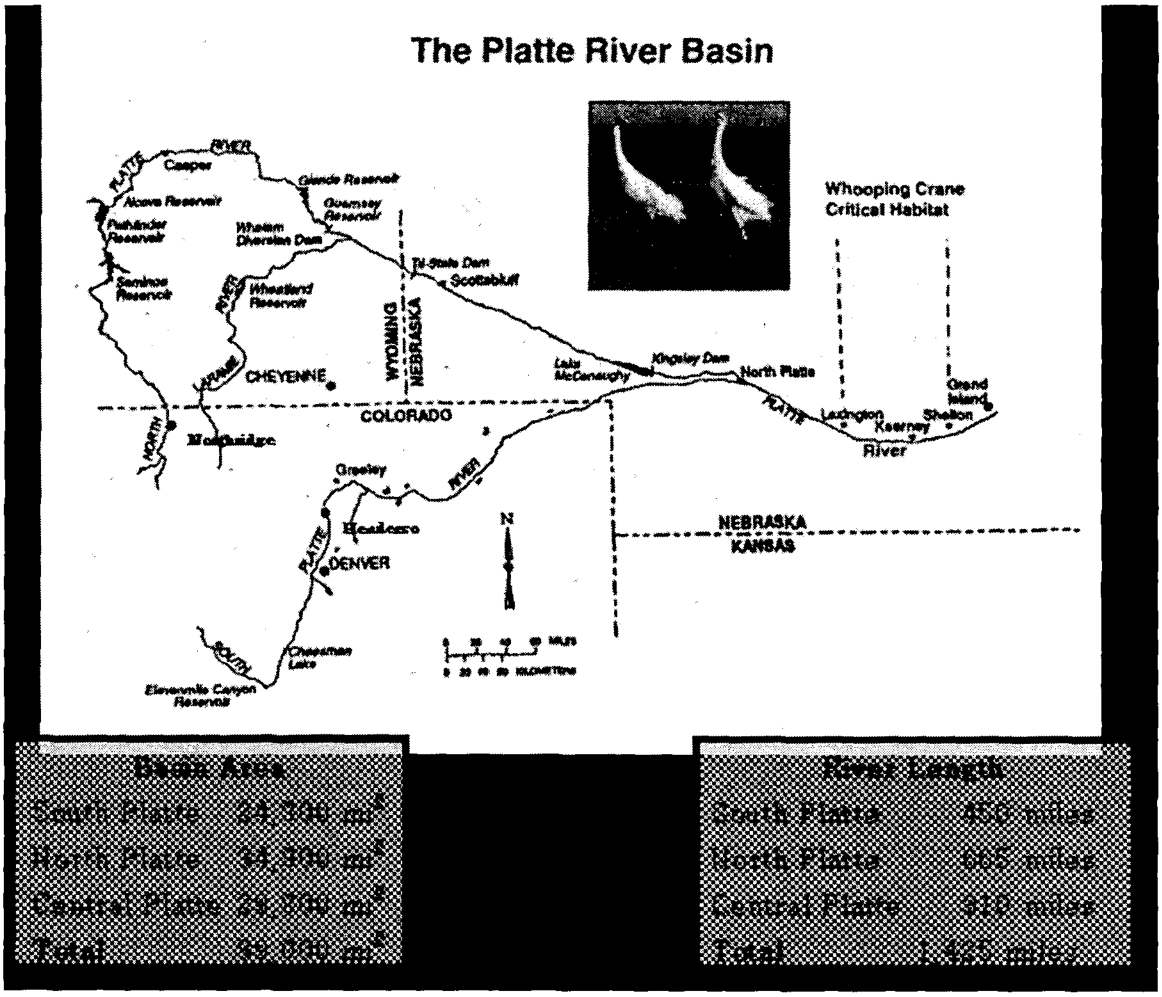


Figure 1. The Platte River Basin

2. Platte River Basin MODSIM Model

A water right system model using MODSIM has been developed as part of an effort to support water resources management decisions for an increase of instreamflow at central Platte River Basin. The River Basin runs from southeastern Wyoming (North Platte River) and Northeastern (South Platte River), across southern Nebraska (Central Platte River) to critical habitat area. This model is a computer software tool developed to simulate the hydrologic operation of MODSIM network for Platte Basin River and water right system on a monthly time step. The model capability includes follwings and Platte River network is presented in Firgure 2.

1) A description of the basin has represented by nodes and links, including the major inflows, diversions and reservoirs in the Platte River Basin.

2) Water rights system for intrastate water use

3) Interstate Compacts (CO/NE, WY/NE)

4) Transmountain water distribution (Big Thormson Project operated by NCWCD, transmountain water from Laramie River Basin)

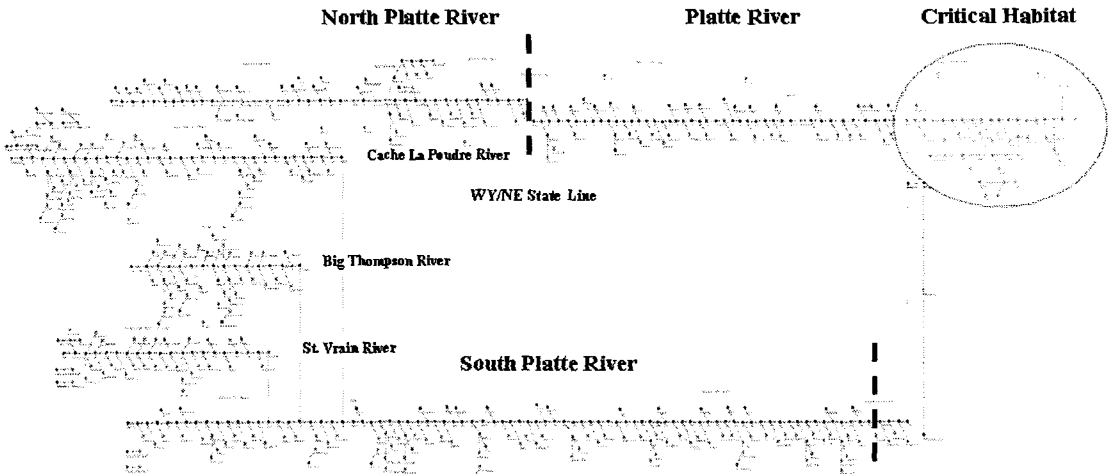
5) Instream Flow Requirements

6) Evaporation, channel, and reservoir seepage losses calculations

7) Crop consumptive use

8) Modeling of stream-aquifer interactions (including conjunctive use of surfacewater and groundwater)

9) An analysis of model runs completed through September 1998.



Nodes	Number
Reservoirs	13
Demands	207
Inflows	74
Gaging Stations	30
Other Nodes	320
Total	644

Links	Number
Water Rights	466
Other	577
Total	983

Figure 2. MODSIM network for Platte River Basin

The water rights system in the Platte River System were represented by the links connected to the demand nodes by assigning the negative cost according to their water right date. Most of the demands have the multiple water rights, and these were implemented by multiple links in MODSIM built in function. To merge the three systems of Colorado, Wyoming, and Nebraska, the different priority zone concept was introduced. The demands in Colorado and Wyoming have the higher priorities than any other demands in Nebraska. The Flow-Through Demand node was applied to the Julesburg to represent the South Platte River Compact. The reservoir operation rules in Nebraska were not explicitly modeled, but modeled with simplified rules of priority and target EOM contents with respect to the diversions in downstream of the reservoirs according to the water right.

Irrigation return flows are the portion of a diversion that is not used by crop consumptive use. As these flows reenter the river system through both groundwater and surface runoff, they affect water distribution with time through the basin and they may be a benefit. To calculate the return flow, the following parameters are required: 1) Irrigation water use efficiency; 2) Timing of the return flow; 3) Locations that return flows occur.

Irrigation water use efficiency can be defined from several standpoints. From the standpoint of this study, the efficiency of irrigation water use includes canal efficiency, farm efficiency, and system efficiency. The principal factors that influence canal efficiency are evaporation, transpiration and seepage and leakage. To calculate the timing of the return flow, Stream Depletion Factor (SDF) technique was chosen. The locations of the return flows were estimated from the stream and canal map and they were calibrated. The amount of the water that returns to the location was distributed according to the canal extension with respect to the stream and they were also calibrated.

3. Model Development: Calibration and Validation of the Model

Two model calibrations including gain loss analysis were performed for the Platte River Model. The 1st calibration (hydrologic calibration) was performed to meet the flow levels reported from the USGS gaging stations along the river, using historical data from the calibration time period for the water deliveries, the canal efficiency, the farm efficiency, return flow lag factors, reservoir seepage lose coefficient, and evaporation. The same data sets and assumptions were used for the simulation to develop the unexplained gain and loss terms with the calibrated parameters from the first calibration result. MODSIM network model was developed by merging 17 reaches and more and used for this simulation run. The artificial source and sink nodes and links were created to identify the gains and losses in the network. The gage flow was forced to meet the historical gage flow at this time. These errors are mainly caused by unaccounted local inflow and pumping effect in addition to by measurement error associated with diversions and stream flow and uncertainty of the ditch efficiency, farm efficiency, return flow lag factors. Including gain, loss, and error terms from the previous step, the second calibration was performed to represent the water right system, reservoir operation and iterstate compact. Only the first 12 years (1975-1986) were used for the calibration and the last 12 years (1987-1998) were used for the model verification. The model was initially developed using available gage, diversion, reservoir operation data so that identify the impact of return flow. Figure 3 shows one of the result of calibration from 17 reaches.

4. Baseline and Alternatives

The Platte River Basin has been divided into 5 regions for the purpose of economic and hydrologic evaluation of the alternatives. The region 1 includes the North Platte River Basin above Whalen diversion dam. The region 2 extends from Whalen diversion dam to Lewellen. The region 3 extends from Lewellen to GrandIsland. The region 4 extends from Kersey to South Platte at North Platte. The region 5 consists of Saint Verain River, Big Thompson River, Cache Poudre River, and South Platte River from Henderson to Kersey. The alternatives were devised to improve instream flow conditions at Grand Island, Nebraska for endangered and threatened species. After the earlier screening of alternatives, the alternatives grouped within the categories of system management, changes of water use efficiency and requirements, recharge (groundwater), water transfers, state instream flow protections, and an environmental account for the purpose of potential transfer of storage rights and customary operations at Lake McConaughy. Each specific representative alternative was used alone or in the combination with a number of others. For this study, the yields and

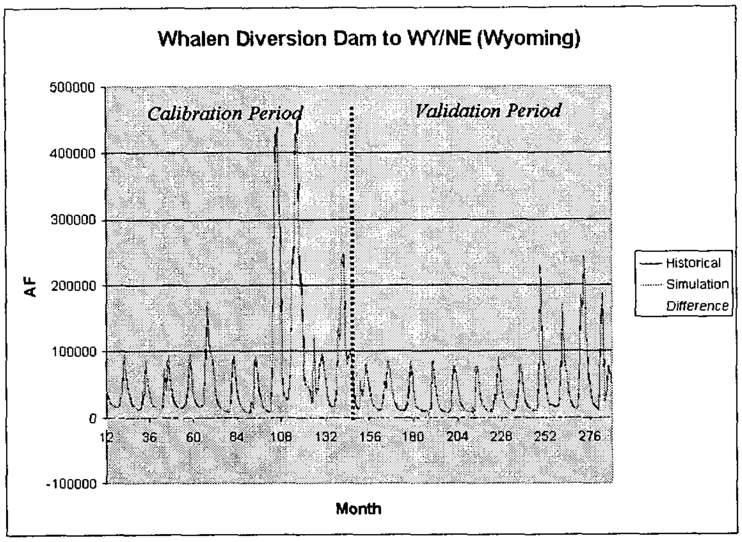


Figure 3. Calibration and Validation Result

hydrologic effects of alternatives is in terms of the average annual values over the period 1975 to 1998. The yield was defined as the reductions to target flow shortages at Grand Island.

The increase of efficiency of canal and farm irrigation system and recharge alternatives increased the target flow shortage at Grand Island. The state instream flow protections did not much impact on the flow increase at the State lines. The most efficient way of reducing the target flow shortage at Grand Islands using environmental account. Using the environmental account is 3 or 5 times more efficient than without using it. The reservoir storage changes alot over the study period when environmental account used alone and just reduced the diversion at region 2 in Nebraska. The most efficient alternative was using the environmental account only. The next efficient one is region 1 water transfer with the environmental account. The diversion changes are highly impacted by the environmental account.

5. Conclusion

The accuracy of the model highly depends on the accuracy of the inflow and diversion data and other parameters associated with return flow. The most of inflow and diversion data are within 15 percent of the true values, and the uncertainty of the return flow parameters exists. The model does not calculate the hydropower generation. The ground water depletions by well irrigation are implicitly accounted for in the simulated gain and lose terms with additional simulation after the first calibration. The fundamental objective of this research is to establish an approach for understanding hydrologic and economic impacts of improving instream flow conditions in the critical habitat. The approach we develop allows quantitative impact estimates of specific policy alternatives for improving instream flows.

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