Management of Montanas groundwater resources - an industrial analysis and case study of Crow Creak valley, Montana
by Virginia Evelyn Worthington

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Applied Economics
Montana State University

Abstract:
The commonality problems associated with groundwater use have led to inefficient allocation and economic waste of the resource. Under an institutional regime of poorly defined property rights, groundwater users fail to consider both the true cost of current extraction activities and the stock value of the resource in their pumping decisions.

This study examines groundwater management in Montana. State groundwater law is reviewed and various management approaches are briefly evaluated. A cursory review of Western states' laws related to groundwater management in areas where use conflicts exist indicates that current Montana statutes provide greater flexibility than most. This is seen as a positive feature in promoting efficient resource use.

A case study using linear and dynamic programming is made of the Crow Creek Valley in Southwestern Montana to demonstrate the use of an optimization model in determining the most efficient temporal allocation of groundwater. Results of the analysis indicate that when groundwater systems are confined, there is a decided economic advantage in maintaining the artesian pressure in the system by not exploiting the stock component of the resource. Marginal pumping costs rise rapidly when groundwater is mined from a confined system. If stocks are depleted to the point where the piezometric surface falls below the confining stratum, the system becomes unconfined and the artesian pressure is lost. If stocks continue to be depleted beyond this level, eventually the system moves to a second equilibrium state.

Sensitivity analysis is used to examine the impact of changes in the discount rate, size of the basin, energy costs and land productivity on the derived decision rule. Energy costs have the greatest impact on the general structure of the optimal use policy. Assumptions about land productivity also have a critical influence. When land is treated as homogeneous, the optimal allocation is identical to that under a common pool setting. With diminishing marginal land productivity, however, the difference in the two decision rules is more pronounced.

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Date 5/25/82

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AN INSTITUTIONAL ANALYSIS AND CASE STUDY OF CROW CREEK VALLEY, MONTANA

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VIRGINIA EVELYN WORTHINGTON

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ABSTRACT

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CHAPTER 1

INTRODUCTION

Water has always been a vital yet limiting resource to the economy of the arid West. In the past surface diversions provided the bulk of water used in agricultural, domestic and mining activities. But over the last several decades groundwater -- subsurface water in soils and geologic formations beneath the water table -- has become an increasingly important source. In 1970, 19 percent of the water used in the U.S. came from groundwater sources (Freeze and Cherry, 1979). By 1980 this figure had grown to 25 percent (Newsweek, Feb. 23, 1981).

Increases in groundwater use have been particularly dramatic in the West where it now accounts for 46 percent of the public supply and 44 percent of the industrial use (Freeze and Cherry, 1979). According to Frederick (1981), growth in western irrigation over the last three decades has been based on the use of groundwater. He reports a three-fold increase in groundwater withdrawals for irrigation between 1950 and 1975. Today these withdrawals account for 39 percent of all western irrigation water (Frederick, 1981, p. 21).

In Montana more than 95 percent of the total water withdrawn is for irrigation (Montana Department of Natural Resources and Conservation, 1975). While currently 99 percent of this water comes from surface sources, the use of groundwater for irrigation has grown

significantly since the 1950s (Figure 1.1).

Unfortunately groundwater users often face less long-term security than do surface water right holders. Supplies and extraction costs are affected by the addition of new wells, increases in pumping rates from existing wells, pollution and higher energy prices. Thus groundwater resources are depletable in both an economic and physical sense. This depletable nature, along with the failure of individual pumpers to consider the true costs of their actions, has created a host of environmental and use problems. Frederick (1981) estimates that more than 22 million acre feet of groundwater is being mined (use in excess of natural recharge) from western aquifers each year. In some areas chronic overdraft has caused wells to go dry, land to subside, aquifers to be tainted with saltwater and pollutants, and surface flows to be altered.

In the past management efforts to combat these problems primarily concentrated on strategies to increase supplies rather than improve the efficiency of water use and the allocation of water rights. Today, however, supply side solutions involving large-scale water projects are no longer feasible for economic, political and physical reasons (Ingram et al., 1979). Thus if groundwater is to continue to be an important part of our water economy, new institutions must be developed to improve the efficiency with which this resource is used