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Groundwater Management in California: Rent-Seeking Behavior under the Correlative Rights Doctrine

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by

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April 13, 1990

Dr. Vincent Ostrom
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Dear Dr. Ostrom:

When you picked up this package from your mailbox, I'm sure you wondered what the heck it could be and why is it addressed to you. Dr. Robert Deacon was my dissertation advisor at the University of California at Santa Barbara. You and he met at a conference a number of years ago, began talking about my dissertation, and you told him to be sure I sent you a copy when I finished.

You should find the first and second chapters very interesting. I owe you and Elenore a thank you for your work in this area (her dissertation contributed to Chapter 3). Basically I argue that rent-seeking led to the adoption of groundwater management in Southern California (South Coast Basin) <u>and</u> rent-seeking prevents groundwater management institutions from being adopted in the San Joaquin Valley. Chapter 4 is a economic model showing the economic gain from groundwater management in the San Joaquin Valley but Chapters 5 and 6 explain impediments to its adoption. October's volume of <u>Contemporary Policy Issues</u> will have a summary article of Chapter 4's results.

If you enjoy the manuscript and think it has publication potential (as Dr. Deacon contends), your assistance would be appreciated. Thank you.

Sincerely,

Nathan Eric Hampton

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ss

Enclosure

Mailed Basin Reports
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ABSTRACT

Groundwater Management in California: Rent-Seeking Behavior
under the Correlative Rights Doctrine

by

Nathan Eric Hampton

Groundwater is managed in California under two separate property rights systems. In the urban portions of Southern California, groundwater rights have been adjudicated. Adjudication modifies the Correlative Rights Doctrine, as established by Katz v. Walkinshaw (1903), by granting private property rights to a fixed quantity of groundwater. Without this modification of the Correlative Rights Doctrine, groundwater use is governed by common property rights. Groundwater use under common property rights, as compared to private property rights, result is a higher rate of overdraft and a lower level of income. Groundwater users in the San Joaquin Valley, despite high rates of groundwater overdraft, have not adjudicated rights to groundwater.

Rights to groundwater were adjudicated in the South Coastal Plain of Southern California because establishment of private property rights allowed those with these rights to capture a rent from groundwater use. Alternative water supplies, mainly from the Metropolitan Water District, were more expensive than the cost of groundwater which encouraged most water users to use groundwater. The demand on the groundwater resources of the area threatened to raise the cost of groundwater and eliminate the cost differential between groundwater and water from the Metropolitan Water District. To protect this cost

differential, and thus the rent-earning capacity of groundwater, the groundwater users on the South Coastal Plain claimed prescriptive rights to groundwater by adverse possession.

Groundwater users in the San Joaquin Valley have avoided collective managment of their groundwater resources. In that the establishment of private property rights to groundwater allows for efficient managment of groundwater, or the optimal control of groundwater extractions, maintaining common property rights to groundwater reduces the income that accrues to groundwater users. A dynamic programming model is used to measure the income that would accrue from the optimal control of groundwater use and this is compared to the income that accrues from groundwater use under common property rights. It is shown that the incentive to establish private property rights to groundwater (i.e. an adjudication of groundwater rights that would allow for the optimal control of groundwater use) is approximately $ 1.209 billion.

Despite this incentive, groundwater users in the San Joaquin Valley have maintained common property rights to groundwater. The reasons for this are many: the rigidities in the allocation of surface water, the large number of water districts, differences in water supply situations across groundwater users of the Valley, and the pricing policies of the major surface water suppliers. Particularly with respect to the last reason, because most surface water delivered to groundwater users in the San Joaquin Valley is priced below the cost of groundwater, rent-seeking behavior is towards securing more of the cheaper water -- surface water-- and not towards the efficient management of groundwater.

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CHAPTER ONE

INTRODUCTION TO GROUNDWATER PROPERTY RIGHTS

I. Introduction

The goal of this dissertation is to analyze the economic incentive to change property rights to a common property resource. A common property resource is a resource to which private property is established only after the resource is reduced to possession from a common pool (where access to the common pool is restricted to members of a specific group), but before capture of the resource from the common pool, property rights to the resource are held in common by a specific group of individuals. Efficient or private property rights have the characteristics of universality (all resources and rights to them are completely specified), exclusivity (all benefits and costs of exercising rights to a resource accure to the owner), and transferability (voluntary exchange should be possible from one owner to another).[1] Private property rights will assure market transactions result in Pareto-efficiency in the absence of transactions costs, monopolies, nonrivalry in consumption, income effects, or increasing returns to scale.[2] However, for common property resources the

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[1] For a discussion of property rights see Tom Tietenberg, Environmental and Natural Resource Economics, second edition, Glenview, Ill.: Scott, Foresman and Company, 1988, pp. 38-40; or Alan Randall, Resource Economics: An Economic Approach to Natural Resource and Environmental Policy, second edition, New York: John Wiley and Son, 1987, pp. 153-162. Each of these authors include a fourth criteria of property rights - enforceability. However, here it is presupposed that a soverign power exists that will sanction, and if necessary protect, the vested property rights. According to Raleigh Barlow, Land Resource Economics, fourth edition, Englewood Cliffs, N.J.: Prentice-Hall, Inc. 1986, p. 387, the existence of property rights presupposes the presence of an owner together with others who can be excluded, property objects that can be held as possessions, and a sovereign power with the ability to enforce property rights.

[2] See S. Cheung, "The Structure of a Contract and the Theory of a Non-Exclusive Resource," Journal of Law and Economics 13 (1970), pp. 49-70.

characteristic of exclusivity is not in force. The benefits and costs of using the resource are not under the exclusive control of the individual, instead any one individual is denied the right to interfere with any other person's exercise of communally owned rights.[3] Private market transactions involving common property resources do not result in Pareto-efficiency.

Groundwater is a common property resource. inefficient use of groundwater results from the common property rights which govern use of groundwater. The laws governing groundwater use do not establish exclusive rights to groundwater until the water is extracted from the basin and brought to the surface. Groundwater in the basin is owned in common by all whose land overlies the basin, according to California's Correlative Rights Doctrine. Because the groundwater in the basin is common property[4] (property rights which define only conditions of use) rather than private property (rights allowing exclusion of others and transfer of the exclusive right, in addition to defining conditions of use), incentives do not exist for individuals to efficiently extract groundwater from the basin. inefficient use results in a level of income less than that level of income to be earned under efficient management. If private property rights are established, both efficient management and an increase in net income for groundwater users will result.

Competitive use of a common property resources reduces the net income that accrues to the users of the common property resource. Because common property rights create an interdependence among users that is unrecognized in individual decisions, a social cost (a

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[3] Harold Demsetz, "Toward a Theory of Property Rights," American Economic Review 57, (May 1967), pp. 347-359, idealizes three forms of ownership: communal ownership, private ownership, and state ownership. The distinction rests in where the power to exclude the other two rests. The community may exclude the private citizen and the state from use of a resource, private ownership implies that the community recognizes the right of the private individual to exclude others, or the state may exclude anyone from the use of a right.

[4] Common property should not be confused with public property. In the case of public property, the state is responsible for the resource, and controls the conditions under which the resource is used. However, under the Correlative Rights Doctrine groundwater is considered the property of a specifically defined group of individuals - overlying landowners.

negative externality) is created for all users of the common property resource. This social cost is not included in the optimizing calculus of economic agents making independent resource use decisions. Exploitation of groundwater under competitive conditions results in an inefficient amount of groundwater being extracted from the basin because the negative externality (due to interdependence across all groundwater extractors) is uncontrolled by the institution of common property rights. Either common property rights must be changed into private property rights, or else competitive exploitation must be eliminated. [5]

The inter dependency among resource users created by common property rights but unaccounted for in individual groundwater use decisions results in groundwater overdraft or "mining" of the groundwater basin. In the context of agriculture, one author has explained the common property externality and the difficulty of its solution as follows[6]:

> Continued and serious overdrawing occurs primarily because of a "common pool" problem. Groundwater is common property and each farmer knows that if he doesn't use it, even to the point of no economic return, somebody else will. Since individual farmers have no exclusive rights to water left in the ground, they tend to disregard the future value of that stored water. Therefore, instead of remaining at a somewhat higher level where most growers can make at least some profit, the entire groundwater basin will be drawn down to a no-profit level.
>
> To correct the "common pool" problem, it has been suggested that management entities be created to manage at least some aquifers in the best interests of the joint pumpers. Legislation has been introduced that would limit groundwater use to the average annual aquifer recharge. Farmers, however have almost

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[5] The common property externality can be eliminated in one of two general ways: a pumping tax equal to the social cost per acre-foot of groundwater extracted can be imposed on each acre-foot of groundwater extracted, or allocation of groundwater among users can be based upon pre-assigned quotas. The first means is a way of eliminating competitive exploitation of groundwater because the interdependence between users is explicitly recognized in individual resource-use decisions. The second means is a way of eliminating common property rights to the resource because the quota establishes an exclusive, and in some cases a transferable, right to groundwater which did not exist before.

[6] B. Delworth Gardner, et al., "Agriculture" in Competition for California Water. edited by Ernest A. Engelbert with Ann Foley Scheuring, Berkeley: University of California Press, 1982, p. 27-28.

universally condemned these proposals and have resisted even local or regional groundwater control.

Groundwater accounts for forty percent of all water delivered for use to Californians every year.[7] Of the 40.5 million acre-feet of water used every year, 83% is delivered to agriculture and 17% is delivered to municipal and industrial users. The state has 9.7 million acres of irrigated land, 4.7 million acres of which are in the San Joaquin Valley.[8] Throughout most of the state, groundwater is more expensive per acre-foot than is surface water, but its supply is much less variable. On those lands for which both surface water and groundwater of comparable quality are available, groundwater is a substitute for surface water. In dry years when less surface water is available, more groundwater is extracted to replace surface water shortfalls, and in wet years when surface water is abundant, less groundwater is extracted which allows allows water to remain in the groundwater basin for use at a later time.

Of the 16.6 million acre-feet of groundwater used every year, 5.8 million acre-feet is from natural recharge, 8.8 million acre-feet is from artificial recharge (e.g. seepage from unlined canals; return flows after initial agricultural, municipal, and industrial uses; and intentional recharge projects), and the remaining 2 million acre-feet (or 12 percent) is from overdraft.[9] Overdraft is the "temporary condition of a groundwater basin where the amount of water withdrawn by pumping exceeds the amount of water replenishing the basin

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[7] California Department of Water Resources, California Water: Looking to the Future, Bulletin 1.60-87, Sacramento: Department of Water Resources, 1987, pp. 16 and 31. Also see Raymond H. Coppock, Robert M. Hagan and William W. Wood Jr., "Introduction: The Problem, The Resource, The Competition." in Competition for California Water, edited by Ernest A. Englebert, Berkeley: University of California Press, 1982, p. 2. Of the 40.5 million acre feet of water delivered for use in the state, 16.6 million acre feet is groundwater.

[8] California Department of Water Resources, Bulletin 160-87, p. 2 and 11.

[9] Ibid., p. 31.

over a period of time."[10] The condition of critical overdraft is a problem in some areas. A critical condition of overdraft exists when it is evident that continuation of present water management practices will result in significant negative impacts upon environmental, social, or economic conditions at a local, regional, or state level. [11] Pumping under "present water management practices" is the cause of the problem of critical overdraft. Of the 248 "more important ground water basins" identified by the Department of Water Resources, 42 show evidence of overdraft, and 11 of these 42 show conditions of critical overdraft.[12] Eight of these eleven basins are in the San Joaquin Valley (see Figure 1-1), which is the nation's richest agricultural region.[13] The other three basins are in predominantly agricultural counties. Therefore, the agricultural sector bears the majority of the costs from conditions of critical overdraft.

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[10] California Department of Water Resources, California's Ground Water. Bulletin No. 118. Sacramento: Department of Water Resources, 1975, p. 4.

[11] Helen J. Peters, "Effect of Boundaries on Groundwater Basin Management." in Proceedings of the Twelfth Biennial Conference on Ground Water. California Water Resources Center Report No. 45. Davis: University of California Water Resources Center, 1979, p. 70.

12 See California Department of Water Resources, Bulletin No, 118, Also, the Santa Barbara County Coastal Basins, the Arvin-Maricopa Basin and the Poso Basin were said to be under conditions of critical overdraft by Helen Peters in Proceedings of the 12th Biennial Conference on Ground Water, ibid.

[13] In California Department of Water Resources Bulletin, No. 118, the basins subject to critical conditions of overdraft are:
(1) Cuyama Valley Basin which stretches across the northeastern boundary of Santa Barbara County,
(2) Ventura County Basin in Ventura County,
(3) Eastern San Joaquin County Basin in eastern San Joaquin County,
(4) Santa Cruz-Pajaro Basin in Monterey and Santa Cruz Counties,
(5) Chowchilla Basin along the border between Merced and Madera Counties,
(6) Madera Basin in Madera County,
(7) Kings Basin in Fresno County,
(8) Tulare Lake Basin in Kings County,
(9) Tule Basin in Tulare County,
(10) Kaweah Basin in Tulare County, and,
(11) Kern Delta Basin in Kern County.

The present water management practices under common property rights have given rise to overdraft in California's groundwater basins. To correct this economic, social, and environmental problem requires the adoption of efficient groundwater management. As overdraft continues, the depths from which groundwater must be pumped increases, and this increased depth increases the cost of pumping an acre-foot of water.[14] Under efficient management the height to which groundwater must be raised is less than under competitive pumping, hence the cost of pumping an acre-foot of water is less under efficient management than under competitive exploitation, The pumping costs saved are the benefits to be gained by changing from competitive pumping to efficient management. A change in management practices, or a change in property rights to groundwater, is a costly procedure which may not be justified on economic or social grounds. Only if the benefits are greater than the costs would a change in management practice be justified on economic grounds.

The switch to efficient groundwater management is not without cost, and the "switching costs" or transactions costs may outweigh the benefits from such a switch. Because of the increased control it exercises over pumpers, efficient management has greater operating costs than competitive pumping. The imposition of control over individual choice may have social ramifications unmeasurable in economic terms. In order for society to justify and implement a switch in management practices, the cost savings from eliminating overdraft must be greater than the sum of the economic switching costs and the social switching costs.

The following sections of this chapter expand on the analysis of how property rights are changed, the meaning of property rights, the difference between private and common property rights, the economic costs of common property rights to groundwater, and the common

[14] In addition to the increased pumping costs, other costs are incurred because of groundwater overdraft. Land subsidence raises the cost of maintaining roads, bridges, canals and other facilities; sea-water or brakish-water intrusion from surrounding basins and other salinity problems that arise from use of contaminated groundwater; and drainage problems that result from overuse of groundwater on lands overlaying an impervious layer of soil.

property aspects of the Correlative Rights Doctrine. Immediately following is a description of the economic theory and methodology of the study to be conducted in the following chapters.

This first chapter is followed by two chapters studying the conditions which led the groundwater users in the southern urban section of the state to institute efficient groundwater management through the adjudication of groundwater rights. Then the next three chapters establish the benefits to the groundwater users in the San Joaquin Valley of instituting efficient groundwater management, and balances these benefits against the costs and constraints of changing the existing common property rights. An optimal control model is used to obtain the time path for net income of groundwater use under two alternative sets of property rights. Any difference in the discounted present value of net income will be due to the economic behavior of groundwater users under these alternative sets of property rights. Furthermore, this difference in discounted present value of net income provides a measure of the benefits to be gained by eliminating common property rights to groundwater.[15] However, a study of the physical, economic, and political aspects of present groundwater use in the San

[15] To measure the change in net income between two different forms of property rights to groundwater, the dissertation uses an optimal control model that combines the economic and physical aspects of groundwater use. Groundwater basins in California can be ranked by this model from highest to lowest according to the gain in net income from changing property rights to groundwater. Those basins at the high end of the scale would benefit most given the change from common property rights to efficient management, whereas those at the low end of the scale would benefit least. Though the gain in net income is an economic incentive to adopt efficient management, other disincentives against the adoption of efficient management need to be combined with the economic incentives to explain the existence or the lack of efficient management.

A change in the rules and regulations governing the withdrawal of water from an underground basin is a change in the property rights to groundwater. A change in the property rights to groundwater will affect the income of those who use the groundwater. If the change in property rights results in an increase in net income, then users, assuming everything else equal, should be willing to accept the change, but if the change lowers the income of the groundwater users they are expected to oppose it. The maintenance or elimination of common property rights to groundwater can thus be analyzed as an economic behavior motivated by the change in net income that results from a change in property rights.

Joaquin Valley will show that the costs of eliminating common property rights are very high. Finally, the last chapter is a summary and conclusion of the previous chapters.

The common property rights to groundwater have been eliminated by the adjudication of groundwater rights in the South Coast Basin of Southern California. To the groundwater users of this region of the state who undertook collective action to eliminate competitive exploitation of their local groundwater basins, the costs of continued overdraft evidently became greater than the costs of efficient management. However, this course of action has not been chosen in the currently seriously overdrafted basin in the state's major agricultural region. To determine if this behavioral choice (i.e. maintenance of common property rights) will continue into the future requires an answer to the question of whether or not the benefits outweigh the costs from eliminating common property rights to groundwater for the groundwater users of the San Joaquin Valley of California. The answer to this question, a major purpose of this dissertation, requires a measurement of the increase in net income from efficient management, and a comparison of this benefit against the costs of instituting efficient management.

II. Methodology

II. A. Institutions as Social Choices

This dissertation is a study of institutional choice. Institutions, such as property rights, affect the efficiency of individual decision-making. Institutions themselves are the result of social choices. S. V. Ciriacy-Wantrup's "hierarchy of decision levels" will be used to explain the difference between individual decision-making and society's choice of institutions.[16] This hierarchy has three levels of decision-making. At the first and most decentralized level, individuals make decisions concerning the efficient use of inputs, outputs and other physical and economic variables, individuals are assumed to be rational in that they recognize the economic consequences of their decisions and attempt to make the most efficient (or welfare maximizing) decisions given existing technological and institutional constraints. Decision-making on the second level controls the institutional framework of the decision-making process on the first level. Institutional restrictions on individual behavior, such as laws, regulations, industrial structure, and other policies, are created at this level. On the third level, which includes the cultural and constitutional levels of decision-making, the framework of the decision-making process on the second level is the subject of decisions. Social or cultural mores and norms which give rise to preferences for decentralized versus centralized processes, preference for democracy versus monarchy, and preference for common law versus civil law have their influence at this third level. Although the subject matter of decision-making differs from level to level, the levies are interrelated because the effects of each level's decisions can be traced through all lower levels. For the purposes of the dissertation, the third level of decision-making will be assumed to remain constant and only the effect that the second level decisions have on the first level will be studied.

Private and public decisions relative to natural resource use involve the impacts that (1) physical, biological, and technological factors, (2) economic considerations, and (3) institutional arrangements have on the social welfare of resource users. These three factors set the limits concerning what individuals, groups, and governments can accomplish in their

[16] S. V. Ciriacy-Wantrup, "Water Policy and Economic Optimizing: Some Conceptual Problems in Water Research" in The American Economic Review LVII. 2, (May, 1967), pp. 179-189. Also see ""Common Property" as a Concept in Natural Resources Policy" and "The Economics of Environmental Policy" by S. V. Ciriacy-Wantrup, as well as the above article and others, in <u>Natural Resource Economics: Selected Papers</u>, edited by Richard C. Bishop and Stephen 0. Andersen, Boulder: Westview Press, Inc., 1985.

natural resource development, utilization, and conservation decisions.[17] First level decision-making specifies an objective (profit or welfare) function, and its goal is to maximize this objective subject to constraints established by institutions, technology, and resource availability. The level of welfare that results depends upon the components of the objective function, the institutional means of optimizing the function, and the severity of the resource constraints. Institutions are constraints in the first level's process of optimization. However, on the second level of decision-making, institutions correspond more to choice variables than to constraints. Efficient management and common property rights are two institutional constraints under which first level optimizing decisions are made. Efficient management and common property rights are institutional structures which are endogeneously decided on the second level but which are exogeneous to the decisions made on the first level.

in terms of the model used in this dissertation, an increase in net income accrues to groundwater users on the first level when efficient management is substituted for common property rights to groundwater on the second level. The increased net income is an economic incentive to undertake the substitution. Though differences in net income are measured as the result of first level decisions, it is on the second level of decision-making where the decision whether or not to maintain common property rights is made.

The purpose of decision-making on the second level is to maintain or to increase welfare by continuously influencing decision-making on the lower level. As conditions change, old institutions (and old decision rules exercised on the first level) may not allow for an increase in, or maintenance of, welfare. The social costs of maintaining the old institutions on the

17 Raleigh Barlowe. Land Resource Economics. 4th edition, Englewook Cliffs: Prentice-Hall, Inc., 1986, p. 4.

second level is the foregone welfare (as measured on the first level), and if these costs become high enough, then forces will be motivated to replace the old institutions with new ones.[18]

Common property rights are a second level institution that guide first level resource use decisions. Common property rights distribute property rights in groundwater among a number of owners who are co-equal in the rights to use the resource. However, if the policy established on the second level with respect to groundwater use also allows for competitive use of groundwater based upon the equating of private marginal costs and private marginal benefits by the resource users, irrespective of the social costs of this behavior, then depletion of the resource will result. Continuous depletion or overdraft of groundwater will adversely affect the welfare of all groundwater users. Solution to the problem of overdraft -- the severity of the problem not being measured by physical quantities of groundwater use but by economic measure of the level of welfare that results from groundwater use -- takes place at the second level of the decision-making hierarchy through a restructuring of the institutions governing use of groundwater.

Decision-making processes on the second (and third) level are part of the political process, yet the political process is similar to the economic optimization process used on the first level. A political optimization process can be interpreted as having as its goal an optimal configuration of institutions on the second level. Choice of one set of institutions as preferred to another requires a performance criteria to allow comparison. According to Ciriancy-Wanthrup, one such criterion is "survival under the pressure of selection.... Here, survival must be interpreted in economic terms; that is, not in physical growth and numbers but in economic growth and welfare."[19] Appraisal of institutions can be accomplished only if it is

[18] As established on the third level of the hierarchy, institutional change requires action taken by the three branches of American government (the legislative, judicial, and executive) at either the federal, or most likely in the case of groundwater, at the local and state level.

19 Ciriancy-Wanthrup, p. 72.

recognized that they function over time under various and changing economic or scarcity conditions. Changes in economic conditions can necessitate a change in institutions if the existing institutional configuration does not allow attainment of the goal of the political process -- increased opportunity for economic growth or increases in welfare.

The desirability of any given configuration of economic and institutional factors, or an economic-political equilibrium, is the contribution it makes to the human condition or to social welfare. One economic technique for measuring the contribution of natural resource use to social welfare is called benefit-cost analysis. When institutions are used as constraints in optimizing models, such as benefit-cost analysis, a new optimum must be calculated for each combination of constraints, and the optima calculated for each different set of constraints must then be compared.[20] A change in institutional arrangements can be integrated into a benefit-cost analysis to determine the direction of change in social welfare that results from a change in property rights. As an integral part of the type of benefit-cost analysis used here, dynamic analysis[21] is employed to describe a time path of net income over time -- one time path for each alternative set of property rights. Different time paths of net income will result from changes in the institutions upon which net income generating decisions are made. By comparing two present values of net income, one before an institutional change and one after

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[20] This procedure is called the Theory of the Second Best. See R. G. Lipsey and Kelvin Lancaster, "The General Theory of Second Best." Review of Economic Studies XXIV, 63, (1956-57); and John v. Krutilla, "Welfare Aspects of Benefit-Cost Analysis." in Economics and Public Policy in Water Resource Development, edited by Stephen C. Smith and Emery N. Castle, Ames Iowa: Iowa State University Press, 1964, p. 22-23.

[21] In dynamic analysis, prices, quantities, profits, and other economic parameters are expressed by their time paths. The movements of these economic parameters over time, as described by their time paths, allow us to describe the effect a change in institutions has on these economic measures. When the time path under one set of institutions is compared to the time path under another set of institutions, the direction or magnitude of the difference in the time paths allows us to say whether or not the institutional change is an economically rational, or efficient, policy for society to adopt.

it, given that only the institutional change took place, will allow a conclusion as to which of the two institutions is preferred.22

If a system of efficient management of groundwater replaces common property rights in an overdrawn acquifer (i.e. a change in an institution), then the desired result of increased net income or profit for those using the groundwater (the change in the economic situation) can be attributed to changes only in the management practice (or property rights) and not to factors outside of the acquifer such as a newly acquired environmental consciousness, the party affiliation of the Governor, or the rate of increase of population, regardless of how interesting these things may be. The cost of restricting ourselves to a partial equilibrium analysis is that our results will hold only for the specific and local situation from which they were derived. This lack of generality is compensated by our ability to compare two given political-economic equilibriums, or time paths, and to attribute an affected change between them to a specific cause.23 However, the robustness of the results is based upon the appropriateness of the assumption that the economic situation is independent and autonomous from the world around it.

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22 Partial-equilibrium is a restriction in the type.of analysis done on a change in an economic situation. Partial equilibrium analysis is the technique of assuming all other possible sources of change are held constant. A change in institutional structure in one market will directly affect the economic variables in that market. But this same change in institutional structure may affect other markets and changes in the economic variables in these other markets will have secondary effects in the market in which the institutional change took place. Depending upon the sensitivity of the relationships among markets, these secondary influences can profoundly affect the behavior of the individuals in the market in which the original change in institutions took place. However, in order to concentrate on the effect the change in an institution has on the market which it directly affects, these secondary or other-market influences are assumed to be of little importance. Markets are assumed to be relatively isolated from one another with little sensitivity between them in partial-equilibrium analysis.

23 E.J. Mishan, What Political Economy Is All About, Cambridge: Cambridge University Press, 1982, p. 30, says "What is meant by an equilibrium is...a state in which all price and quantity adjustments have been made, so that the particular set of prices and quantities that prevail during this state can be taken as the economic characteristics of the equilibrium situation being compared."

In terms of groundwater institutions, focus is on how these institutions on the second level affect the welfare of groundwater users. Second level institutions (i.e. water district law, groundwater law, water pricing policy, or water district financing) influence the optimizing decisions on the first level (i.e. decisions on the timing and quantity of groundwater use) and also influence the level of welfare that results from those decisions. Water institutions affect the welfare of whole regions in various periods of its development. institutions designed to foster growth in the early periods of a region's development may be poorly suited to continuing that growth once the area matures and pressures of resource scarcity impinge upon It. If a region is to survive, it must modify its water institutions so that an increase or maintenance of welfare is possible given the changing constraints of resource scarcity.

II. B. The Economic Meaning of an Improvement in Social Welfare

Assuming we can make the choice between an existing equilibrium situation (i.e. common property rights), and an alternative economic situation (i.e. efficient management by adjudication of groundwater rights), Mishan warns that, "In general, any such change affects the welfare of one or more of all persons in the community (landowners overlaying the groundwater basin), and affects each one for better or for worse. Manifestly such a change has distributional effects. Yet quite irrespective of the pattern of the distributional change in the community's welfare, the economist vaunts a criterion by which he can pronounce on the economic efficiency alone of the movement from (one equilibrium situation to another)." [24] It is assumed that an individual can put an objective measure on his welfare, and furthermore, if everyone's welfare is assumed to count, and if everyone's welfare can be objectively combined, then a measure of "social welfare" can be obtained by aggregating the individual welfare of all

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24 Ibid.

members of the society, or community. An improvement in social welfare is one criterion by which social or institutional choices can be analyzed as efficient, and Justified as desirable.

"Welfare" should not be given too general an interpretation. Its economic meaning has less to do with happiness, well-being, or utility then it does with "willingness to accept" or "willingness to avoid" a change in a given economic situation. Social-psychological attributes (or preferences) of an individual, though they influence one's valuation of a change in an economic situation, are assumed to be constant so that willingness to accept or willingness to avoid provide a consistent and objective measure of welfare change. If the change from economic situation A to economic situation B makes person "1" better off to such an extent that he is willing, at most, to pay x-dollars for the change, then x-dollars is his increase in welfare. If person "2" is to be damaged by the change from A to B, he would be willing to pay a certain sum, y-dollars, to avoid the change, and we can say a negative y-dollars, is his change in welfare from the change from A to B. A third person, person "3," may be indifferent or unaffected by the change, so he would be unwilling to pay anything at all to bring about the change or to avoid the change, so his valuation of the change in his individual welfare would be zero-dollars.

Upon aggregation of individual welfare, the change in social welfare caused by the change from situation A to situation B could be (x-y+0) -dollars.[25] if this total is positive (i.e. x>y), the economist concludes there is a net social benefit from the change, or that situation B is economically "more efficient" than situation A. Likewise, if the value of the aggregate in social welfare is negative, than situation B is considered to be less efficient than situation A, or a net social loss is said to result from the change. However, a positive value of the net social welfare is not enough for an economist to propose the change from situation A to

25 Addition of the individual valuations assumes everyone's welfare counts equally. Other means of aggregating individual welfare are possible.

situation B, unless the change is a possible "Pareto efficient" change.26 under possible Pareto efficiency, if the gainers from the change can compensate the losers for their losses, with the end result being that no one is left worse off and at least one person is left better off after the compensation has been paid, then the economist can conclude that the change in economic situation has resulted in a net gain in social welfare, and is a socially desirable policy to adopt.

We can call our measure of social welfare "net income." Changes in net income, as a measure of the change in social welfare, can be used to compare two equilibrium situations. In our study of groundwater, since those who pump the water out of the ground are the same ones who use it, the net income to be derived from using groundwater accrues directly to the groundwater user. Because groundwater use takes place over time and net income thus accrues over time, the present discounted value of net income will be our measure of the value of aroundwater under any given set of property rights. A different set of property rights will change the present discounted value of net income. If the present discounted value of net income after a change is greater than the present discounted value before the change, then the change is said to increase social welfare, or result in a net gain of social welfare. The net gain in social welfare is the benefit to society of adopting the new set of property rights. However,

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[26] Pareto efficiency requires that when a change from one economic situation to another transpires, the end result is that no one is made worse off and at least one person is made better off. This concept of (strict) Pareto efficiency would require that all individuals' welfare changes are non-negative, which in the example above is not true. Though the net gain in social welfare is positive if $x>y$, the fact that person 2's valuation is negative rules out the change from A to B as being strictly Pareto efficient. Rather than "strict" Pareto efficiency as a criterion for judging the acceptance of changes in economic situations, we shall adopt the idea of "possible" Pareto efficiency, wherein if the sum of all the individuals' welfare changes is positive, then the gainers could compensate the losers from such a change with a surplus left over for further distribution. As in the above example, since $(x+y+z) > 0$ the change from situation A to B is a possible Pareto efficient change. See Robert C. Lind, "Benefit-Cost Analysis: A Criterion for Social Investment" in Water Resources Management and Policy, edited by Thomas H. Campbell, and Robert 0. Sylvester, Seattle: University of Washington Press, 1968, pp. 44-64.

no change in property rights will be costless, and if these costs of implementing the change, the "transactions cost," are greater than the above economic benefit, then society is unlikely to make the change.

III. Property Rights As Institutions

III. A. Defining Property Rights

Property rights may be defined as the interests which can be acquired in external objects or things. They express social relationships across individuals with respect to some property object, such as groundwater. [27] The value of one's interest in a property object, or natural resource, varies depending on one's ability to appropriate (to use) the resource, to exclude others from using the resource, and to transfer the right to use the resource to others. Efficient private property rights include the three powers to appropriate, to exclude, and to transfer.[28] Common property rights do not include the latter two powers. Property rights, whether private or common, are a social institution that guides individual behavior, and are a determinant of the level of welfare that results from that behavior.

The "bundle of rights" concept of property explains the type of interests individuals can have in property, and the various property right structures that society can institute. Raleigh Barlowe explains the bundle of rights concept as follows:[29]

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[27] E. G. Furubotn and S. Pejovich, "Property Rights and Economic Theory: A Survey of Recent Literature," Journal of Economic Literature X,4,(Dec. 1972), say that a property right refers "to the sanctioned behavioral relations among men that arise from the existence of things and pertain to their use."

[28] See Richard A. Posner. Economic Analysis of Law. third edition. Boston: Little, Brown and Company, 1986, pp. 30-33. Incentives to use resources efficiently are created by "parceling out among the members of society of mutually exclusive rights to the use of particular resources." But the attainment of efficient use of resources also requires that the exclusive rights be transferable. Posner suggests "three criteria of an efficient system of property rights" are universality (all resources should be owned or ownable by someone), exclusivity, and transferability,

[29] Barlowe, p. 331-332.

> Property involves several distinct interests or rights, which can be held separately and which taken together represent a "bundle of rights." The largest bundle of rights a private owner can hold in landed property is known as complete ownership or as ownership in fee simple. Fee simple owners ... have the right to possess, use, and within reason exploit, abuse, and even destroy their land resources....
>
> Fee simple ownership is one of the broadest and most complete concepts of property ownership yet developed. Yet it must be recognized that the fee simple owner holds exclusive, not absolute, rights. Ownership rights are always limited and conditioned by the overall interests of society administered by the state....

Landed property is only a subset of all objects which can be called property and made subject to fee simple ownership. The bundle of rights concept of property rights divides property into two categories: the separable rights of private or individual ownership, and the rights reserved to the state or government. Property rights are separable rights because any one individual may not have the complete bundle of rights. Attenuation of the fee simple private property right occurs when society's goals are incompatible with individual goals under absolute private property rights. For example, riparian water rights grant to the individual the right to use water, but the individual is not allowed to transfer his riparian water right separate from his land because the subsequent reduction in return flows would cause damage to his neighbor's right to water.

Society has the power to control an individual's use of his property rights. Private property rights are not absolute rights allowing the individual to do anything he desires with his property, but are exclusive rights that allow the benefits from use of property to accrue exclusively to an individual. (It is the absence of this exclusion clause that characterizes common property rights from private property rights). Paired with the privilege of accruing exclusive benefit is the responsibility that the exercise of private property rights has socially desirable consequences. Private property rights are an institution sanctioned by society and the exercise of private property rights are subject to social direction or control. The rights reserved to the state to assure individual behavior is compatible with society's goals include the right to tax, to take for public use (eminent domain), to regulate (exercise of police powers), and to own.[30] These public rights infringe upon the exercise of private rights. The mixture of private and public rights, the configuration of property rights engineered by society, is called the structure of property rights.

The structure of property rights is a basic institution of society, where institution is defined as "collective action in control, liberation, and expansion of individual action."[31] As proposed here, the absolute private bundle of rights should not be confused with the most liberating and expanding bundle of rights, for collective action which combines private and public rights can satisfy some human needs which private action alone cannot. As summarized by Barlowe:[32]

> With this (general welfare or social theory of property) approach, one may argue that society is the true fount of property rights. Society allows individuals (or those who count in the eyes of the ruling group) to acquire, exercise, and maintain property rights and thereby maximize their personal satisfactions, because this procedure usually enhances the prevailing concept of "social welfare." In an ultimate sense, however, society always retains its right to regulate the allocation and distribution of property rights; and as the interests and goals of society change, the institution of property also changes.

The structure of property rights that exists at any time in a society is a dynamic balance between private rights and public rights. Society, whether or not through a consciously perceived role, directs and controls the use of its resources, by creating and maintaining a given balance between private and public rights. Society's acceptance of any given property rights structure depends upon how efficiently the incentives imparted by that structure work toward attainment of society's goal. Given an understanding that different

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[30] For a discussion of how the power to tax, eminent domain, exercise of police powers, spending powers, and the use of proprietary powers are used by society to plan the use of its natural resources, see Chapter 12, Property in Land Resources, in Raleigh Barlowe, Land Resource Economics. 3rd edition, Englewook Cliffs: Prentice-Hall, Inc., 1978, pp. 394-432.

[31] John R. Commons. Institutional Economics: Its Place in Political Economy. Madison: University of Wisconsin Press, 1959, p. 5.

[32] Barlowe, p. 334, cf 13.

property rights structures impart to individuals differing incentives which result in various behaviors, a change in property rights has an effect on the net income of the users of a natural resource. In some respects, the value of any given property rights structure can be measured by the net income it accrues to society, if other non-economic goals of society are held constant.

An efficient property rights structure will maximize society's net income. Such a property rights structure has the characteristics of universality, exclusivity, and transferability. If the characteristic of exclusivity is absent, as in common property rights, than individuals will not bear all of the consequences of their actions or decisions. This situation is referred to as an externality. An externality exists whenever the welfare of an individual depends directly not only on his own actions, but also on decisions under the control of some other individual. As economic interdependences increase, so too must the efficiency of property rights structures increase if society is to avoid diminished levels of welfare.[33]

Property rights evolve over time in response to many environmental factors, and their structure at any given moment always wields a powerful influence in shaping attitudes and actions concerning how resources can or should be used.[34] As increased scarcity of resources sews a web of conflict and interdependence among individuals, the greater will be the demands upon the structure of property rights to direct individual behavior in the attainment of societal goals. Population and technological growth have increased economic interdependence

[33] The state of California inherited fee simple ownership of groundwater when the state adopted English common law. California's Correlative Rights Doctrine initially introduced common property rights to groundwater because it removed existing barriers to groundwater use under fee simple ownership, and removal of these barriers was intended to facilitate economic growth. However, it was also recognized that as growth continued there would develop interdependencies or externalities among users of the groundwater resource, so the Correlative Rights Doctrine provided means to subsequently improve the efficiency of property rights to groundwater by the elimination of common property rights and the establishment of private rights to groundwater.

[34] Barlowe, p. 9.

in this country during the twentieth century, and public responses to the increased interdependence, each involving a more complex form of public planning (e.g. the Progressive Movement, the New Deal, the Great Society Program, and the Environmental Movement), is a characteristic of twentieth century American politics. The beliefs in rugged individual ism, "that government governs best which governs least," and in the "invisible hand" that coordinates individual actions to bring forth the optimum in social welfare (known as the "laissez-faire doctrine") have been modified by the recognition of the benefits from collective decision-making under conditions of increased economic interdependence.

As explained by Raleigh Barlowe.[35]

> As long as most (fee simple) owners adhere to common goals in the productive use of their lands, there is little need for more formal planning. But when some individuals begin to pursue goals that are in direct conflict with those of other owners or that run counter to the perceived interests of members of society, a case arises for the provision of additional community guidance in land use. At this point, society can exercise its inherent vested interest in securing orderly and effective use of its resource base to discourage unwise and wasteful practices, which may prove injurious to owners, their neighbors, their communities, or society at large.

Property rights to groundwater, as embodied in the groundwater law of various states, have undergone substantial changes in response to the environmental conditions found in the West. One purpose of this dissertation is to explore the extent to which California's groundwater users have secured orderly and effective use of groundwater.

III. B. Common Property Rights

Common property refers to a distribution of rights in resources in which members of the defined community are legal equals in their rights to use the resource.[36] The institutional equality-in-use is caused by an inability or unwillingness to exclude others from use, and

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[35] Ibid., p. 485.

[36] A. Allan Schmid, Property, Power and Public Choice, New York: Praeger Publishers, 1978, p. 53.

results in an inability to transfer the resource to its highest and best (economic) use.[37] All users have a common right to use the resource and suffer the consequences of the inability to exclude or transfer. Paired with the common property right in a common pool resource is a set of incentives which results in the inefficient use of the resource.

Ciriacy-Wantrup and Bishop explain common property as a social institution[38] as follows:

> The term 'common property' as employed here refers to a distribution of property rights in resources in which a number of owners are co-equal in their rights to use the resource. This means that their rights are not lost through non-use. It does not mean that the co-equal owners are necessarily equal with respect to the quantities (or other specification) of the resource each uses over a period of time. In other words, the concept as employed here refers to resources subject to the rights of common use and not to a specific use right held by several owners. In the legal literature this distinction appears as "common lands" on the one side and 'tenancy in common' on the other.
>
> Sometimes both the institution and the resources subject to the institution are called the "commons." It is helpful, however, to differentiate between the concept, the institution, which in many variations makes the concept operational in reality, and the particular resource that is subject to the institution. In any event economists are not free to use the concept 'common property resources' or "commons" under conditions where no institutional arrangements exist. Common property is not "everybody's property." The concept implies that potential resource users who are not members of a group of co-equal owners are excluded. The concept "property" has no meaning without this feature of exclusion of all who are not either owners themselves or have some arrangement with owners to use the resource in question. For example, to describe unowned resources (resnullius) as common property (res communes), as many economists have done for years in the case of high seas

[37] A. Alchian, and H. Demsetz, "The Property Rights Paradigm," Journal of Economic History, (1973), define a "communal right" which includes only the right to use but does not include the right to exclude. The absence of the ability to exclude and to transfer are transactions costs associated with reallocations of property rights. Also, A. Alchian, "Toward a Theory of Property Right" American Economic Review 57, (May 1967), p. 347.

[38] s. v. Ciriacy-Wantrup and Richard C. Bishop, ""Common Property" as a Concept in Natural Resource Policy," Natural Resources Journal 15, (October, 1975), p. 714-715,

> fisheries, is a self-contraction... they are very different in actual and potential institutional regulation.

Of particular importance in the above is the treatment of exclusion. Though common property "owners" can exclude nonmembers from use of the resource, they cannot exclude members from undertaking conflicting uses of the resource.

Because common property rights are an incomplete form of private property rights, individuals have Incomplete incentive to use the resource efficiently. Dasgupta[39] gives the following example of the incentives that exist, and of the type of inefficiency that results with a common property resource:

> Consider first underground water basins. While it is easy enough to envisage different individuals in a community having titles to adjacent plots of land, owning titles to the water underground is an entirely different matter. (This problem occurs as well in the case of oil and natural gas if the rule of capture prevails.) One usually does not know precisely how much water lies below a given surface area of land, even when there is a reasonably sharp estimate of the total stock in the entire basin. Add to this the fact that nothing is easier for a farmer than to extract water from under his neighbor's plot without anyone being the wiser, and one can see why private-property rights on aquifers are difficult to define, let alone to enforce. One can of course define such rights by legislating that all water that lies under a given parcel of land belongs to the owner (or lessee) of the parcel. But this is not useful, since there is a tendency for water to migrate within the underground basin and thereby altering the extraction costs of neighbours, particularly so when pressure gradients are caused during the process of extraction. The source of the problem here lies in the uncertainty as to the original location of a given quantity of water extracted at a given location.
>
> In the face of this problem most communities have fallen back on the "riparian doctrine", under which each owner of a parcel of land is allowed to extract as much water as he desires without regard to its effects on the owners of neighbouring parcels. Th8 doctrine therefore provides no protection to a well-owner from the lowering of the water table under his land caused by his neighbour's actions. This suggests at once that in the absence of any intervention (e.g. rationing at the well head through

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[39] Partha Dasgupta, The Control of Resources. Cambridge: Harvard University Press, 1982, p. 15-16.

> cooperation) the doctrine will encourage an excessive rate of overall water extraction, leading possibly to an eventual ruin of the basin. This possibility is particularly telling if in fact it is in the community's long-term interest to keep the basin alive. But if the circumstances are such that this is a distinct possibility the question can be asked why the farmers do not see the impending destruction of the basin.... Moreover, and this is particularly important, under the riparian doctrine no farmer on his own has much incentive to learn about the natural regeneration rate of the ground-water basin. Under the riparian doctrine, each farmer is much like the traditional "free-rider"....

Common property rights to groundwater are inefficient because those laboring under these rights are not able to make resource use decisions which maximize group welfare. No single resource user, or in this example a single farmer using groundwater, has an incentive to reduce groundwater use to the social optimum because he would bear all of the costs from reducing groundwater use (i.e. the lost profits from not pumping) yet receive no benefits (i.e. lowered extraction costs from a raised groundwater table) unless everyone else agreed to do likewise. Even though the group as a whole might be better off by cutting back on groundwater extraction, any individual lacks the incentive to do so. In terms of property rights, the costs to reduce groundwater pumping are incurred to produce the benefit of a raised groundwater table, but the rights to this benefit are not exclusively owned by the individual. Others cannot be excluded from this benefit, hence overdraft of groundwater continues, groundwater costs rise, and the profits from farming drop. Though the group as a whole may receive benefits in excess of the costs from mutually agreed upon groundwater use reduction, the individual has no incentive to reduce groundwater use in the absence of such an agreement.

The essence of the common property resource problem is that each individual is prevented from exercising the resource use strategy that maximizes his individual welfare because of the economic interdependencies and incentives inherent in common property rights.[40] The value of the individual's resource use decision is affected by the decisions made by the other users of the common pool resource. It is in the interest of each user to come to an agreement restricting the level of use to the Pareto efficient (prof1t-maximizing) level, but the benefit from such restriction is not perceived by the individual when the resource is used under common property rights.

Two conditions create the common property externality: (1) nonexclusive use and (2) adverse interaction among users. These conditions result in the inability of individual decision-making to attain efficient management of the resource. Nonexclusive use of the resource results in a level of use that, in conjunction with adverse interaction or congestion among the users of the resource, increases the cost of production thus lowering the profit earned by the resource users. All common property problems involve overuse or excessive exploitation of the resource because a social cost (or foregone benefit) is neither borne nor taken into account by the decision makers who are exploiting the resource. Solution to the externality requires either instituting some form of exclusive use, or mitigating the adverse interaction among the users.

111. C. Economic Aspects of Groundwater Use Under Common Property Rights

Economics is applied to issues of groundwater use because groundwater is a scarce natural resource. Scarcity means that the amount available is limited relative to the amount

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40 The essence of the common property resource problem is that each individual is prevented from exercising a cooperative strategy because of the incentives inherent in common property rights. The efficiency of the individual's production decision depends upon the production decision of all of the other users of the resource. It is always in the interest of each to come to an agreement restricting the level of output to the Pareto efficient profit-maximizing level, but the benefit from such restriction does not accrue exclusively to the individual when the resource is a common property resource. However, when property rights are at the discretion of resource users, then it is their inability to change property rights that prevents them from attaining the cooperative strategy. See P. Dasgupta, and G. Heal, Economic Theory and Exhaustible Resources. Cambridge: James Nisbet and Cambridge University Press, 1979.

demanded, resulting in a positive price or opportunity cost. A change in the relative scarcity (i.e. changes In the cost or price) of a resource such as groundwater means that there has been a change in the sacrifices required to obtain a unit of the resource. The sacrifices which must be made to use a resource vary according to the physical characteristics of a resource. Resources can be classified as stock resources or flow resources. The distinguishing characteristic of a flow resource is that it is available in some predetermined quantity and must be used when provided or otherwise wasted. A stock resource is one whose quantity is fixed or given and can be exhausted or used up but no more can be made or created. Using either a flow or a stock resource requires incurring the sacrifice or costs to extract the resource and put it to productive use. However, use of a stock resources carries an additional cost component, called a user cost, which is not incurred from the use of flow resources. If a unit of a stock resource is extracted today, it is not available tomorrow. The present discounted value of this foregone future opportunity is a sacrifice made by use of a stock resource.

Flow resources are different from stock resources because they are naturally regenerated on a time scale that is relevant to human exploitation. Catching a fish or cutting a tree does reduct the population of fish or trees in any period, but this is normally temporary because within relatively few periods natural growth will make good the loss in biomass due to the harvest. This is obviously not the case for an exhaustible resource like oil or groundwater. Units remaining in the stock after others have been extracted do not grow or regenerate. Use of a stock resource reduces the number of remaining units of the resource by an amount equal to the number of units used.

Stock resources are treated as capital goods in economic analysis. A capital good is an aggregation of physical goods or produced means of production which are transformed into final consumption goods by a production process. The existence of capital goods (i.e.

intermediate goods used to produce future goods) implies that there was a sacrifice of current or past consumption in order for capital to have been accumulated. Rules governing the use of capital goods require that use proceeds at a rate which will maximize the "capital value" of the resource. Capital value refers to the present value of a stream of future payments. The future payments are earned by use or liquidation of the capital stock.[41]

The extraction of groundwater is the liquidation of a capital good and involves certain expenditures necessary to remove the groundwater from its basin. Once extracted from the basin, groundwater is indistinguishable from water from any other source, and need not be considered the same as capital. But groundwater in the basin is capital because the more groundwater in the basin, the lower will be the cost per unit of water extracted. The opportunity cost of extracting groundwater is less when more groundwater is in the basin, because the water table in the acquifer will be higher, and the effort required to bring the water to the surface will be less. Hence, water left in the basin provides a future benefit in the form of a lower future extraction cost (i.e. stream of future services). Water in an aquifer represents a capital asset which can be held for the above reason, but the value of this asset will also depend on the availability of other water sources.

Water left in the basin, to raise the groundwater table and to lower future extraction costs, is an investment. Present income is foregone when water is left in the basin because water not extracted today does not produce additional units of output which could provide additional units of income. The value of the present income foregone is the cost of leaving the additional units of water in the ground. The benefit from the investment is the lower future extraction costs which would result from having the water table higher. How much will be the efficient amount of investment? Water should be left in the basin until the present value of

[41] See J. Hirshleifer. Investment, Interest and Capital. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1970, pp. 40-41.

the lowered future extraction costs (the marginal benefit of investment) equals the value of the present foregone consumption (the marginal cost of investment). Efficient management of groundwater will allow for that rate of groundwater extraction such that the marginal benefit of the last unit of groundwater left in the basin equals the marginal cost of-leaving it there.[42]

To groundwater users operating under common property rights, the perceived marginal (private) benefit of investment is zero, and the rational decision for the individual is to undertake no investment. The marginal benefit of Investment is zero because though one Individual may leave water in the basin, there is no way for him to enforce his rights over that water. Other users of the basin may extract the water which any one individual left in the ground. Only once the water is brought to the surface can an individual establish and enforce his property rights to the resource. Under common property ownership of groundwater resources, the marginal (private) benefit of investment (i.e. leaving a unit of groundwater in the basin) is zero, so groundwater is extracted until the marginal cost of leaving an additional unit of groundwater in the basin is zero (i.e. present profits are maximized).

The necessity to extract the water out of the basin before property rights can be established is called the rule of capture. The rule of capture[43] is stated in the negative - - a landowner loses title to any groundwater underlying his surface property if it migrates away

42 The behavior of resource users under efficient management has been explained by Charles W. Howe. Natural Resource Economics. New York. John Wiley and Son. 1979, p. 244-5, by connecting the total costs of producing a given level of the natural resource and the property rights in the resource. When the early units of the resource are recovered at relatively low cost, they earn a "rent" or excess profit, while the last units produced earn no profit because marginal cost has risen to equal price. If the resource users (firms in an industry) share among themselves the exclusive right of access to the resource, they would protect this rent on the early units of production by refusing to expand output past where price equals marginal cost and by either refusing admission to any more users or by selling out to new users only at a price equal to the capitalized value of the rents being earned. Any buyer would experience only the going rate of return on its total investment, so there would be no motivation to expand use of the resource under this "usual private property situation".

43 See Brown v, Vandergrift. 80 Pa. 147, (1875): Westmoreland and Cambria Gas Co. v. DeWitt. 130 Pa. 235,(1899); and Brown v. Spilman. 155 U.S. 665, (1895) for the application and development of the rule of capture with respect to petroleum resources.

before the groundwater can be "reduced to possession." Similar to the basic philosophy that allows adverse possession -- that if one does not defend his property he explicitly grants it to those who make better use of It — the rule of capture disallows a claim to damages against a neighbor who has reduced to possession a portion of the resource from out of the common pool.[44] According to the rule of capture, groundwater is a fugitive resource that belongs to the landowner who captures it through wells located on his land, regardless of the cost this inflicts upon other users. The other owners of the common pool resource can protect their rights only by drilling a well and taking possession of the groundwater before it migrates away to another's well, and before the costs of extraction rise to unprofitable heights.

Because of the rule of capture, water left in the ground cannot impart any savings in future extraction costs directly and exclusively to the individual who does the saving. Seen in this light, the height of the water table in the basin takes on the characteristics of a public good. Public goods are those goods which are not subject to exclusion but are subject to jointness in use[45]. Water left in the ground lowers the extraction costs of all pumpers from the acquifer, hence they jointly consume the benefits (lower extraction costs) of any water which is saved underground. Furthermore, since property rights to water cannot be established under the rule of capture until the water is brought to the surface, saved water is not subject to exclusion.

[44] Some resources that become private property only after being reduced to possession from out of a common source are not burdened by the rule of capture but by a "public trust doctrine". Rather than treating the common source as a property to which all users have equal access, the public trust doctrine establishes public ownership of the resource. The private individual gains ownership only under the direction and control of the state. See Greer v. Connecticut. 161 U.S. 519,(1895) for an application to animals free in nature, and National Audubon Society v. Circuit Court of Sierra County. 170 C. 3d, (1979) for an application to surface water and environmental resources.

[45] Vincent Ostrom and Elinor Ostrom, "Public Goods and Public Choices," in Alternatives for Delivering Public Services - Toward Improved Performance, edited by E.S. Savas, Boulder: Westview Press, 1977, p. 7.

IV. Common Property Aspects of California's Groundwater Law

IV. A. Introduction

According to English common law, property rights to land granted to the individual, who owned the surface land, ownership of the soil below the surface in a cone to the center of the earth and ownership of the air above the surface in a cylinder to the heavens. Though land stays in one shape and one location, groundwater migrates below the surface of the land maintaining neither shape nor location. Despite this difference, the English common law held that groundwater was the property of the surface landowner, and could be mined as if it were a mineral found in the ground. Even though groundwater would migrate from under one person's land to under another's, the damage done to the former, from lost emigrate groundwater, was not seen as an injury to his property rights.

The English common law was replaced in California by the Correlative Rights Doctrine at the beginning of the twentieth century. Under the Correlative Rights Doctrine all owners of land overlaying the aquifer have equal right to use groundwater. Rights to use groundwater are granted, but no exclusion rights are established. Private property rights over groundwater are established only after the water has been "reduced to possession" or extracted from the aquifer. As will be explained below, the Correlative Rights Doctrine established common property rights to groundwater, with the consequence being common property rights problems of overuse.

Institutions governing groundwater use have evolved within an institutional framework created by over eighty years of judicial, legislative, and administrative guidance. The judicial branch of government has been the main engineer of present groundwater use practices. The following will present the chronology of major decisions made by the California Supreme Court with respect to groundwater. Modification of the Correlative Rights Doctrine by the adjudication of groundwater rights, which establishes exclusive rights to groundwater, has been an incomplete process. Adjudication has been limited to the major urban area of southern California, and has not progressed to the agricultural San Joaquin Valley.

IV. B. Development of the Correlative Rights Doctrine by the California Supreme Court

Since the 1903 case of Katzv. Walkinshaw[46] the California supreme court has applied the Correlative Rights Doctrine to establish and measure the rights of groundwater users. An individual's right to groundwater were established in relation not only to the amount of water in the basin but also in relation to the demands of other groundwater users because, according to the court, "In short, the members of the community, in the case supposed, have a common interest in the water. It (groundwater) is necessary for all, and it is an anomaly in the law if one person can for his individual profit destroy the community, and render the neighborhood uninhabitable."[47] The Correlative Rights Doctrine, as established by this case, instituted the institution of common property rights to groundwater. Furthermore, no mechanism was established to control the competitive instincts of groundwater users, even though they were required to "equally" share the resource. The rule of capture prevails over users of groundwater, and though it has been modified in certain urban portions of the state, it continues to dominate the groundwater use decisions of most of the agricultural sections of the state.

Just as a direct transplant of the English common law's riparian doctrine was not accepted by the California supreme court, though the legislature authorized the use of the

46 Katz v. Walkinshaw 141 C. 116,(1903).

47 Katz v. Walkinshaw 141 C. 116,(1902). Judge Temple presided over this first case decided on November 7, 1902. The plantiff asked for an injunction against the defendant's diversion of groundwater to land not overlying the basin on the grounds that such a diversion infringed upon the plantiffs riparian rights. Riparian rights were denied to exist in groundwater. Both users could use water only for reasonable purposes, and the defendant was prevented from appropriating such water that would result in detriment to the plantiffs (adjoining landowners) rights. The case returned to the Supreme Court the next year with Justice Shaw writing the majority decision which established the Correlative Rights Doctrine.

English common law in an 1850 statute[48], a direct grafting of the English common law's groundwater doctrine to California's water law was likewise eschewed. Recognizing that the English common law holds that the owner of the soil owns to the lowest depth all that is found below,[49] Justice Temple declared that:[50]

> The case is very different, however, in an arid country like southern California, where the relative importance of percolating water and water flowing in definite water courses is greatly changed. And it seems to me a great mistake is made in supposing that, if the plenary property of a landowner in percolating water is denied, the alternative is to apply to such water all the rules which apply to the use of water flowing in water courses having defined channels. The entire argument for what may be called the 'cujus est solum doctrine' consists in showing that some recognized regulation of riparian rights would be inapplicable.... It is (rather) a question of reasonable use, and that applies both to the land of the person disturbing the percolation and to adjoining land.... This rule of reasonable use answers most effectively the main argument against recognizing any modification of the 'cujus est solum doctrine' as applied to percolating waters....

By this ruling Judge Temple not only separated groundwater law from surface water law, but he laid the seed for the "correlation rights doctrine" which is the basis for all subsequent groundwater rulings. Judge Temple's ruling adopted reasonableness as the guide to rights in a groundwater acquifer -- with the admonition to "so use your own property as not to injure that of another." A use of groundwater that unduly infringes upon the rights of another user is an unreasonable use of groundwater. Users of the groundwater, furthermore, did not have the right to pump water so as to unreasonably diminish the amount of water available to other

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48 See Theodore H. Hittle, The General Laws of the State of California, from 1850 to 1864 Inclusive. San Francisco: H. H. Bancroft and Company, 1865.

49 The cujus est solum. eius est risoue ad infernos doctrine. But more important to Judge Temple's ruling was that portion of English common law which held that the consequences of anyone's actions to the groundwater conditions of a neighbor was injury without damage. Because no damage was suffered, no one was able to sue, prevent, nor obtain compensation for lost groundwater which emigrated from beneath one's property, or failed to flow beneath one's property.

50 Katzv.Walkinshaw. 141 C. 116, (1902), p. 666.

users. All users were encouraged, but not required, to recognize the effect upon community welfare created by their interdependent use of a common water source.

When the case reappeared before the California supreme court one year later, Chief Justice Shaw made the following ruling that expressed the philosophy which guided all subsequent groundwater law In California:[51]

> The true doctrine is that the common law by its own principles adapts itself to varying conditions, and modifies its own rules so as to serve the ends of Justice under the different circumstances — a principle adopted into our Code by section 3510, Civil Code: "when the reason of a rule ceases, so should the rule itself."
>
> The principles which, before the adoption of the Civil Code, were applied to protect appropriations and possessory rights in visible streams, will, in general, be found applicable to such appropriations of percolating waters.... Such rights are usufructary only, and the first taker who with diligence puts the water in use will have the better right.... Such rights are limited at most to the quantity necessary to use... Disputes between overlaying landowners, concerning water for use on the. land, to which they have an equal right, in cases where the supply is insufficient for all, are to be settled by giving to each a fair and Just proportion. And here again we leave for future settlement the question as to the priority of rights between such owners who begin the use of waters at different times.

In this ruling Chief Justice Shaw makes two remarkable conclusions. The first is the explicit statement that the rights to water are based upon the rule of capture. The second is that in times when the amount available is less than the amounts claimed by all the users, the water will be allocated according to a fair and Just proportion. This means that cutbacks in the amount of use will not be made by time priority as is the case with the surface water appropriation doctrine, but by some as vet unknown but reasonable means. However, the court left it to the initiative of the water users themselves to request a fair and just allocation of the water. It is a central topic of this dissertation to explain why some water users acted on this initiative and why others did not.

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51 Katzv.Walkinshaw. 141 C. 116, 74 P. 766, (1903), p. 767 and 772.

Perfecting rights to groundwater through "reasonable use" and the allocation of groundwater in times of shortage according to a "fair and just proportion" are the twin cornerstones of the Correlative Rights Doctrine. Regardless of whether there was an abundance or a shortage of groundwater, any use of groundwater must be a reasonable use if it was to withstand a challenge before the court. Since markets did not exist to efficiently allocate the scarce resource and since time priority was judged inapplicable to groundwater's appropriation doctrine, if there was a shortage of groundwater such that all reasonable uses could not be satisfied, the court's mechanism for allocating the available supply was to prorate the amount available to each user by a fair and just proportion. Rights in groundwater were held in common, the rights were mutual and reciprocal, and the costs incurred from a shortage of groundwater were to be allocated likewise. Groundwater rights were not vested in the individual, but instead the groundwater was treated as common property to which each user had an equal right. If nature provided too little supply, or if users demanded more than was available, the court required each user to bear the cost of this shortage.

Ironically, though the court's statements appear to prefer allocation mechanisms similar to the appropriation doctrine rather than the riparian doctrine, the allocation mechanism of the Correlative Rights Doctrine has the same consequences for groundwater users as the riparian doctrine has for surface water users. Under the riparian doctrine, all users share equally in the surface water, each being unable to diminish the quantity or quality of water available to others. If the amount of water available to all is diminished, the amount available to any one user is likewise diminished. This allocative mechanism correlates changes in the quantity of water physically available with changes in the amount of water each user can appropriate. Under California's Correlative Rights Doctrine, all users can expand use of water in times of surplus but all users could have their rights restricted in times of shortage.[52] Mechanisms for placing restrictions on any user's right to groundwater were not put in place at this time though it was recognized that they would be necessary in the future.. Restrictions could be applied only at the request of the groundwater users and would require a judicial determination of each individual user's groundwater rights.

Summarizing his ~~Katz v. Walkinshaw~~ decision and emphasizing its importance as a part of the common law, Chief Justice Shaw in his 1922 article in the ~~California Law Review~~ said,[53]

> "The rights of the owners of different parcels of land situated over a water supply of that character (underground), with respect to each other, and with respect to the use of the water on the overlaying land, are mutual and reciprocal. They are regarded as persons having different interests in a common estate in such waters. Each is entitled to only a reasonable use of such waters on such land and may take no more than his reasonable share for that purpose.... In this the court followed the fundamental principles on which the common law is founded, rather than the rules for technical application to special subjects adopted for practical use in the different conditions prevailing in the countries from which we derive that law.... It is a good example of the elasticity of the common law, showing its adaptation to the varying conditions of human life in countries other than that of its origin."

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[52] Non-overdrafting amounts of groundwater are available, on average, in an amount equal to the safe yield of the basin, but the actual amount available will vary about this mean quantity. The Correlative Rights Doctrine correlates the rights to extract or capture groundwater with the amounts actually available in the basin. If there was water in the basin in excess of the safe yield (i.e. the basin had surplus water), then correlative rights to groundwater would allow extraction of the safe yield plus the amount of the surplus. But if the amount of water in the basin was below the safe yield (i.e. the basin would suffer overdraft if extraction was equal to the safe yield of the basin or the average amount of extraction), then extractions should be limited to below the safe yield. However, judicial restricts on extraction rights needed to be preceded by a determination that the existing rates of extraction were causing undue costs upon all extractors from the basin. Extraction in excess of the safe yield was to be allowed as long as the benefits from such exercise of correlative rights (i.e. increased economic growth from use of groundwater) did not exceed the costs (i.e. increased extraction costs from the lowered groundwater table). If the costs exceeded the benefits, than exercise of correlative rights in excess of the safe yield would be deemed unreasonable, and this unreasonableness would justify a modification of the Correlative Rights Doctrine.

[53] Lucien Shaw, "The Development of the Law of Waters in the West," California Law Review X(September, 1922), p. 459.

The unique physical, economic, and social environment of California allowed and required the court to create the Correlative Rights Doctrine for groundwater.

In the next major groundwater case to reach the supreme court, ~~Cohen v. La Canada Land and Water Company et al~~,[54]: Judge McFarland based his ruling exclusively on the foundations laid down in ~~Katz v. Walkinshaw~~: "...the right of an owner of land to use water percolating therein is a right only to a reasonable use thereof for the benefit and enjoyment of his land, ...and does not include the right...to diminish the flow of water to others, where the diversion is not for a reasonable use on his own land."[55] The question as to what uses are reasonable or not is laid down through statutes and by court precedence. However, what is reasonable at one time and under one set of circumstances (e.g. extraction of groundwater in excess of the safe yield of the aquifer) may not be reasonable at another time or under different circumstances, but waste of water was always an unreasonable use. Water is wasted if it is applied for some purpose from which no benefit is received as is illustrated in the case known as ~~Ex parte Elam~~.[56]

In Ex parte Elam the court required Mr. Elam to cap an artesian well on his property because, allowing the water to flow unregulated and unused from the well was an unreasonable use of water. Here is found a clear example of the court's procedure of circumscribing an ever smaller set of uses which can be deemed reasonable, or, in other words, a removal of a stick from the private bundle of rights to the public bundle by exercise of the state's police powers. The court said, "Whatever right one has, even in his own, is subject to that established principle that his use shall not be injurious to the rights of others, or of the general public. As we have before attempted to show, no surface owner possesses the right to extract the

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54 Cohen v. La Canada Land and Water Company, et. al., 142 C. 437, 76 P. 47,(1904).

55 Ibid., p. 48.

56 Ex Parte Elam, 6 C. 233,91 P. 811,(1907).

subterranean water in excess of a reasonable and beneficial use upon the land from which it is extracted. Any additional extraction is not in the exercise of a right, if by such exercise the rights of others are injuriously affected."[57] Reasonableness cannot ever be conclusively and finally defined, because, though reasonable use is a property right one enjoys with respect to groundwater, one's interest in the groundwater which flows from a source common to many users is subject to the uses and interests of others. These uses and interests of others change over time, and so does the measure of reasonableness which guarantees one's right to use water.

In these earliest of cases, the court had been required to rule on conflicts involving competing overlying landowners who were using the same acquifer. As economic and population growth on lands not overlying groundwater led to water use in excess of surface supplies, enterprising men sought to augment the surface supplies with groundwater. It was a simple procedure to drill a well into an acquifer and lay some pipe or cut a ditch from the well to the land needing the water. However, this added demand on the underground water led to a lowering of the water table and to increased pumping costs for all who had access to the acquifer. Furthermore, the lowering of the water table led to a fear by those landowners overlying the basin that all of the water in the basin would soon be appropriated to far away lands.

[57] Ibid., p. 813. Ex parte Elam is a ruling by the court on the Constitutionality of an Act 4/6/1907 (St. 1907, p. 122, c. 101) which declared it a nuisance to allow an artesian well to flow unabated. The court ruled that the legislature, in laws that restrict pumping from groundwater acquifers to protect the public welfare, does not deprive anyone of property without due process. The court claimed, "Whatever right one has, even in his own, is subject to that established principle that his use shall not be injurious to the rights of others, or of the general public. This act therefore relates to waters, the right to use of which is common to a large portion of the community, and affects the general public right. Legislation in relation thereto affects the public welfare, and the right to legislate in regard to its use and conservation is referable to the police power of the state" (p.812).

~~Burr v, Maclay Rancho Water Compa~~ny[58] distinguished between the rights of groundwater users whose lands overlay the basin against the rights of those users whose lands did not overlay the basin. The plantiff, who owned land riparian to groundwater, sought to prevent the use of the groundwater on lands not overlying the acquifer by asking the court to limit the amount of water the defendant could transport to lands not overlying the acquifer. The supreme court decided "The reasonable rule here would be to hold that the defendant's appropriation for distant lands is subject to the reasonable use of water on lands overlaying the supply.... If the adjoining overlaying owner does not use the water, the appropriator may take all the regular supply to distant land until such landowner is prepared to use it and begins to do so.... The judgment should be... to limit the amount taken by all the consumers to a quantity, as near as may be, equal to the average constant supply from the rainfall."[59] This ruling shows the court's willingness to not simply adjudicate conflicts over water rights, but to accept the extra-judicial responsibility of determining administrative rules for water management.

One important characteristic of the supreme court's management role is its definition of surplus water as that amount of water in excess of the average constant supply. An exact measure of surplus water required scientific expertise not yet available to the court, but the court's interest was not in an exact physical measurement but a measure that would distinguish between reasonable and nonreasonable use of groundwater. The ruling allocates to nonoverlying appropriators only that water which is surplus to the reasonable needs of the overlying landowners. In addition to creating two classes of water -- surplus and average constant supply -- the court also created two classes of water users -- those whose land overlays the basin and those appropriators whose land does not.

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[58] Burr v. Maclay Rancho Water Company 154 C. 428, 98 P. 260,(1908).

[59] Ibid.p.264.

The nonoverlying landowner could use the groundwater only so long as those overlying the basin did not put the water to reasonable use. The overlying landowners have correlative rights to the groundwater, but the nonoverlying landowners have but a usufructary right only to that water which is surplus water. Surplus water is that water not needed by the overlying landowners for reasonable uses, yet is within the safe yield of the aquifer. When the surplus vanishes, the rights of the nonover lying landowners are extinguished. Furthermore, if the reasonable uses of the overlying landowners are in excess of the available supply, then the Correlative Rights Doctrine calls forth the administrative procedure of Just and equitable cut-backs in the allotment of groundwater among all the overlying users.

IV. C. Modification of the Correlative Rights Doctrine

Growth in population and economic pressures led many urban centers to search for additional water supplies to sustain and encourage further growth. The City of Los Angeles went to the Owens Valley in search of excess water supplies, the City of San Francisco went to the Hetch-Hetchy Valley for its water supplies, and some cities in southern California searched underground to obtain their municipal water supplies. The 1921 case of City of San Bernardino v. City of Riverside et al.[60], begins an era of groundwater law that is dominated by public agencies. The Correlative Rights Doctrine and the common law dictum of reasonableness remain the cornerstones of the law, but their form and application are changed.

Misinterpreting the Katz v. Walkinshaw ruling that the overlaying landowners had a "public Interest" and hence correlative rights to the groundwater, the City of San Bernardino, which overlayed the basin in question, sought to have itself claimed the protector of this public interest with the power to prevent the City of Riverside from transporting

[60] City of San Bernardino v. City of Riverside et al. 186 C. 7, 198 P. 784, (1921).

groundwater to its city limits. But Chief Justice Shaw ruled that "...a city situated in a watershed over an underground basin or reservoir has no rights in the water thereof as being subject to public use for the common benefits of its inhabitants or owners of the overlaying lands, on the theory that the city is the administrator of such public use and has become substituted to the individual rights of owners for the benefit of all, but such water is private property, and the city's rights are only those of an appropriator."[61] By declaring groundwater as private property, the city's only option to reduce the groundwater to public ownership is through eminent domain.

Through eminent domain, a public agency condemns private property for public use. Such condemnation requires compensation to the private individual for his lost property. However, the city, as an owner of property overlying the basin, has rights to the groundwater equal to any other appropriator — a right limited to that quantity of water used for reasonable uses and subject to just and equitable cutback in times of shortage. And the City of Riverside was limited in Its appropriations only to the surplus water in the basin.

Chief Justice Shaw, who wrote the decision establishing the Correlative Rights Doctrine in Katz v. Walkinshaw. reiterates it here by applying it to the cities involved in the case:[62]

> The original title to such (ground) water was in the owner of the land in which it is found. Originally in this state it was assumed that this title was absolute, and that each landowner could take out as much of such underground water as he pleased, regardless of the effect thereof on other lands, provided he took it on his own land, and without a malicious intent to injure others.... In cases presenting these facts the original assumption of absolute ownership in such waters was held untenable under the conditions existing in this state, and the doctrine that the respective rights of owners of land in the waters percolating or lying beneath the surface are reciprocal and correlative as to each other was adopted.

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61 Ibid., p. 784.

62 Ibid., p. 787 and 789.

> No one, not even the owners of overlaying land, has the right to take water out of the watershed for any purpose, if such taking will deprive of water any lands within the basin.

In addition to eminent domain, City of Pasadena v. City of Alhambra et al.[63] made it possible for a public body to gain a right to groundwater through adverse possession. Under adverse possession, if the titled owner of a property suffers damage to his property by the actual, continuous, notorious, and hostile possession for a statutory period of time by claimant in order that the titled owner, without actual notice of such possession, may be legally presumed to have notice of the actions of the claimant, then the claimant is granted actual possession and right over the property.[64] The purpose of adverse possession is to facilitate conveyances[65], and to transfer property resources to their highest and best use. If the titled owner takes no action to prevent the claimant's possession, then it is assumed the claimant values the property higher than the titled owner.

Overdraft, the pumping of groundwater in excess of the "average constant supply," was a severe problem in the Raymond Basin, which contains the cities of Pasadena, Alhambra, Arcadia, Monrovia, Sierra Madre, and other groundwater users. The overdraft was so severe and had persisted for such a long time that in his ruling in City of Pasadena v. City of Alhambra et al., Chief Justice Gibson Ignored established groundwater law and instead declared all parties had gained adverse possession to the quantity of water they had pumped continuously over the previous five years. In the spirit of the correlative rights doctrine, it was then declared that the burden of curtailing the overdraft was to be placed proportionately on all parties. Each party's "decreed right" to the groundwater was set at approximately two-thirds of the amount to which it had gained adverse possession.

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[63] City of Pasadena v. City of Alhambra et al. 33 C. 2d 908, 207 P. 2d 17,(1949).

[64] Steven H. Gifis, Law Dictionary. Woodbury: Barron's Educational Series, Inc., 1984. See "notorious possession" p. 318.

[65] Henry Ballantine, "Title by Adverse Possession," Harvard Law Review. 32. (1918). p. 135.

The court enjoined all pumping in excess of the decreed right and appointed a "Water Master" to enforce the judgment. Though there was no legal precedent for the Chief Justices's ruling and its subsequent administrative procedures, he explained his actions by saying, "Moreover, it seems probable that the solution adopted... will promote the-best interests of the public, because a pro tanto reduction of the amount of water devoted to each present use would normally be less disruptive than total elimination of some of the uses."[66] Though the ruling may have caused minimal disruption in this one basin, it caused a "race to the well-pump" over the next thirty years in the surrounding basins which were likewise overdrafted. Municipalities and water companies sought to maximize the amount of water they pumped in the event that a similar ruling would restrict their future pumping rights to some percentage of the current amount pumped.

~~City of Pasadena v. City of Alhambra. et al.~~ provided the legal mechanism for modifying the Correlative Rights Doctrine. The common property rights of the Correlative Doctrine Doctrine could be substituted for private property rights to groundwater. However, these rights must be distributed in a fair and equitable proportion among those with private rights to groundwater. According to ~~City of Pasadena v. City of Alhambra. et al.~~ a fair and equitable proportion could be established through adverse possession. The supreme court subsequently modified the above decision in ~~City of Los Angeles v. City of San Fernand~~o.[67] The court said, "A true equitable apportionment would take into account more factors than the five year previous to complaint amount."[68] Herein the court maintained us ability to administer groundwater extractions by establishing a watermaster to oversee the extractions, but it did not limit itself to the five-year-previous-to-complaint rule to establish a limit on extractions.

[66] Ibid., p. 32.

[67] City of Los Anoeles v. City of San Fernando 123 C. 3d 1,(1975).

[68] ibid.

In City of Los Angeles v. City of San Fernando, the City of Los Angeles was importing water from Owens Valley, and the cities of Glendale and Burbank — the actual defendants in the case — were importing water from the Colorado River through the Metropolitan Water District. The court ruled that the return flows and artificial storage from these imports were to be credited to each city's quota. Because these return flows and imports, within the previous five years, had created a surplus of water over the "average annual supply" of the basin in its natural condition, no adverse possession could be established. Though no mutual prescription was found, the court retained "the exercise of such administration and Jurisdiction to conserve and apportion water in overdrawn basins."

V. Rent-Seeking as the Motivation for instituting Groundwater Management

Groundwater users in California's largest urban region -- an area bordered by San Bernardino to the east, the San Fernando Valley to the north, the Pacific Ocean to the west, and Orange County to the south (See Figure 1-2) -- have instituted efficient groundwater management by adjudicating groundwater rights. Severe overdraft, threatening to lower the welfare of groundwater users, provided sufficient motivation for the groundwater users to initiate adjudication and to formalize and implement plans for equitable and efficient distribution of groundwater. Severe overdraft likewise threatens the future welfare of groundwater users in California's San Joaquin Valley, however no efforts have been made to change groundwater rights.

The chapters that follow attempt to explain this difference in behavior by exploring the conditions that led to the adjudication of groundwater in the South Coast Basin, the motivation for adjudication in the San Joaquin Valley, and the constraints against adjudication. It will be shown that no one explanation exists for the difference. The physical, economic, and institutional environments in which groundwater users act vary considerably, thus differences in behavior are to be expected. However, prospects for the acceptance and Implementation of efficient groundwater management in the San Joaquin Valley can be determined from the experiences of groundwater users in the South Coast Basin.

Nevertheless, economic theory does suggest one reason why, if facing the same proposed loss from continuation of common property rights, the groundwater users in the San Joaquin Valley would not pursue the same course of action as groundwater users in the South Coast Basin. Water users generally do not distinguish between groundwater and surface water except by the cost of the water. The two types of water are physically interchangeable or perfect substitutes, given that there are no quality differences between them. However because of differences in the relative per-unit cost of the two types of water, they are not perfect substitutes in an economic sense. If choosing between the two types of water of the same quality, water users will use that water which is priced lower, Furthermore, given the difference between the costs of the two types of water, it can be expected that given a water shortage (i.e. signaled by an increase in the cost of water), water users will attempt to obtain ~~more of the lower cost water~~.

Any user who uses both types of water earns a rent, or surplus return, from each unit of the cheaper type of water used. To increase this rent, the water user will seek to increase the quantity available of the cheaper water. Actions motivated by the opportunity to increase one's rent from resource use are called rent-seeking behavior. The opportunity to earn rent requires a price or cost differential between two resources, such as the difference between surface water and groundwater. if the price differential is eliminated, so is the rent. In the South Coast Basin, groundwater represented the cheaper of the two sources of water (Metropolitan Water District water was more expensive) and so the groundwater users were motivated to protect their rents from groundwater by adjudicating groundwater rights. However, in some portions of the San Joaquin Valley groundwater is the more expensive type of water (in those areas where the alternative surface water is from local rivers or from the Bureau of Reclamation which subsidizes its water prices), yet in other portions of the San Joaquin Valley groundwater is less expensive than surface water. The result of having surface water as the cheaper of the two sources is that efforts are put into the acquisition of additional surface water and not into the protection of groundwater.

The opportunity to capture rent motivates the behavior of the water users in both the South Coast Basin and the San Joaquin Valley. Because the water, whose use allows the capture of rent, is different (because of differences in relative price), the behaviors of the water users are different. South Coast Basin water users have created institutions which allow the capture of rent by those water users who have access to groundwater. San Joaquin Valley water users have created institutions, and continue to pursue behaviors, which allow the capture of rent by the use of surface water. From the perspective of the state as a whole, this has created two different groundwater property right structures within the state. Though exclusive property rights have been established in the South Coast Basin, common property rights prevail in the San Joaquin Valley.

The following section looks at the the effect common property rights to groundwater have on rent-seeking opportunities. Common property rights result in overdraft of groundwater and severe overdraft threatens to lessen the incomes earned by groundwater users because the costs of extraction are raised. The efficient management of resources such as groundwater, called common pool resources because of their fugitive nature, require agreements among the community of users. These agreements must recognize the unique physical characteristics of the resource which are used in common, and of the economic consequences of different property rights to the resource. Common property rights, a set of rights not allowing exclusion of others to the use of the resource, will dissipate any rents which can be earned from use of the resource. If rents are to be earned, some form of property rights allowing exclusion must be created. The following section discusses alternative means of exclusion which can be used to achieve efficient management of a common pool resource.

VI. A Theory for Institutional Analysis of Common Pool Problems[69]

VI. A. Problems in Managing Common Pool Resources

Common property problems arise from the use of common pool resources (fugitive natural resources such as oil, fish, wildlife, and groundwater) whenever the following conditions are present: (1) ownership of the resource is held in common, (2) a large number of users have independent rights to the use of the resource, (3) no one user can control the activities of other users or, conversely, voluntary agreement or willing consent of every user is required in joint action involving the community of users, and (4) total use or demand upon the resource exceeds the supply. Severe conditions of overdraft have plagued various groundwater basins in the state of California because the above conditions were present. As a result of overdraft, groundwater extraction costs rise, and the profit or income derived from use of groundwater decreases.

When the above conditions hold, efforts by any one user of the common pool resource to increase his supply or share of the resource leads to adverse effects on others. The fugitive nature of the resource means that one's extraction of groundwater lowers the groundwater table for everyone using the basin, and hence one person's actions impose increased extraction costs on others. These external-to-the-individual costs, or social costs, are not felt by the individual unless exclusive rights to the resource can be established. But as long as common property rights prevail, the economic calculus followed by any one user will lead him to

[69] The following section is a summary of Vincent Ostrom and Elinor Ostrom, "A Theory for Institutional Analysis of Common Pool Problems," in Managing the Commons edited by Garrett Hardin and John Baden, San Francisco: W. H. Freeman and Co., 1977.

Increase utilization of the resource until his marginal costs equal his marginal benefits. The quantity of groundwater any one extractor uses is determined without taking into account the external costs he creates for other users.

A social consequence of the individual economic calculus of the resource user who is confined by common property rights, is the lack of incentive to invest in capital projects or in institutional arrangements which would provide a common benefit. Even if the total benefit exceeds the total cost, the specific benefit to any single user will rarely exceed the total cost. Thus, the single user, within the myopic and individual economic calculus of common property rights, does not pursue courses of action (i.e. the adjudication of groundwater rights) with widespread common benefits. Furthermore, there are many external, common, or joint benefits which are also ignored under common property rights just as many external costs are also ignored. According to Vincent and Elinor Ostrom, "The essential problem in managing a common pool resource is how to reduce the joint costs and increase the joint benefits so as to improve the net welfare of the community of users."[70]

A single user, changing only his own action so as to take into account the social costs he creates, will seldom have much effect on the whole system unless all other users also change their behavior similarly. It is only when efforts can be made to change the economic calculus of all similar actors that a real social benefit can be achieved. A single user will not voluntarily reduce his demands upon the common pool resource if any other user is free to terminate a voluntary agreement regarding utilization of the resource. It is necessary to forego voluntary agreements, or willing consent, as the decision rule in order to enforce joint benefit-creating decisions on all parties. Solutions to common property problems, therefore, inevitably involve some form of public organization to assure collective decisions that can be enforced against all users.

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[70] Ostrom and Ostrom, p. 158.

VI. B. Solutions to the Management of Common Pool Resources

VI. B. 1. Single Ownership or Monopoly

One solution to the problems inherent in managing common pool resources is to reduce the number of users of the resource to one. This can be accomplished by allowing intensive competition to force out all other users but one, who then acquires a monopoly position over the resource. However, unless the monopolist is forced to behave in a socially desirable way, the social welfare consequences of resource use by a monopolist may not be an improvement over the results under common property rights.

A single owner is able to establish exclusive rights to the common pool resource and hence, the potential for an efficient outcome exists. The City of Los Angeles established exclusive control over groundwater in the San Fernando Basin and in the Owens Valley Basin. This allowed the City to eliminate the adverse interaction or joint costs that arose from having many users independently pursuing extraction decisions while ignoring the interdependencies that existed among users of a common pool resource. The City repeatedly sued other users of groundwater as a means of extending and protecting its right to the groundwaters of the San Fernando Basin, and eventually established exclusive property rights to groundwater.

VI, B. 2. Formation of Public Agencies or Enterprises

As the costs of intensive competition from common property exploitation of a common property resource mount, the community of affected users will have an economic incentive to seek some common solution to their joint problem. This was the expected course of action which would lead to modification of the Correlative Rights Doctrine's common property aspects. The reduction of joint costs, through the adoption of exclusive property rights or some similar institutional arrangement which takes social costs into consideration, represents a potential benefit which encourages community action. The potential benefit, in the form of reduced joint costs or increased joint benefits, according to Ostrom, "can be conceptualized as a potential political (or community) surplus available for capture by those who develop institutional arrangement to undertake joint management and development of the common pool resource."[71]

Establishment of new institutional arrangements requires the allocation of the benefits and costs of the new institution. The political surplus will be captured most by those who can slant the institutional policies or rules in their favor. The form of the new institution, and the directions in which it (re-) distributes wealth, will be a product of the effort of those adept at forming public organizations to make collective decisions. Modern theories of public choice show that either by capture of the institution or by initially determining the rules of the game, the joint benefits from eliminating common property rights may fall in the hands of a very few. Though the total welfare from resource use is larger, the distribution of it may be so narrow as to make more members of the resource using community worse off than before.

Use of the coercive authority of the state will deprive some resource users of free choice, and this may be interpreted as, or actually result in, a decrease in welfare for these users. The "deprivation costs" or decreased welfare created by new political institutions will be lower the closer the policies that are adopted by the new institution agree with the preference of those who use the resource, the closer decision rules conform to majority rule, and as the proportion of individuals that must agree with a decision increases. On the other hand, making decisions and forming agreements are costly behaviors. Effort devoted to collective decision-making, or "decision-making costs", will increase along with the proportion required to agree with a decision, with variance in the preferences of those affected by a policy, or with the number required for decision-making in a public institution.

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[71] Ibid., p. 160.

The sum of decision-making costs and deprivation costs (I.e. transactions costs), plus the cost of operating the management plan, give the total cost of institutionalizing collective action. If these costs are less than the benefits (reduced joint costs, or increased joint benefits) from collective action, then an institution for collective action should be formed, i.e. a political surplus exists. Political surpluses appear to have existed in the groundwater basins of the South Coast Basin. The pattern followed in each basin in the institutionalizing of collective action was (1) the establishment of a groundwater user's association, (2) the adjudication of groundwater rights which granted exclusive rights to those groundwater users with a long(5-year) history of use(i.e. adverse possession), (3) the establishment of control over extraction either by injunction against pumping greater than a given quota of groundwater or by the charging of a per-unit tax upon groundwater extraction and the purchase of surface water to replenish the extracted groundwater, and (4) the annexation of the basin to the Metropolitan Water District to secure additional supplies of water.

Such steps have not been taken by groundwater users in the San Joaquin Valley. Nonetheless, many surface water districts in the San Joaquin Valley have had their taxing and spending powers extended to include taxing of groundwater extraction and purchase of replenishment water. However, because there are so many water districts in the San Joaquin Valley, none originally or exclusively designed for groundwater management, and because their boundaries are too small to encompass more than a portion of the individuals affected by the problems of common property rights to a common pool resource, any individual district is not able to make welfare-increasing groundwater use decisions. The welfare of the groundwater-using members of a single district is affected by the groundwater use decisions of surrounding districts as well as the district's own groundwater policy. Because individuals do not have exclusive property rights to groundwater, the water districts of the San Joaquin Valley cannot undertake welfare maximizing groundwater policies.

To have efficient groundwater management within the existing institutional structure of the San Joaquin Valley may require either a single or small number of institutions with jurisdiction for comprehensive planning and with the ability to envision and realize many of the particular benefits desired by small groups, or a complex structure of incentives and deterrents among the numerous existing agencies functioning in a public enterprise system so the external costs created by each district will be taken into account in its relationships with other districts. The cost of institutionalizing this form of collective action is substantial, apparently greater than the benefits, since the common property problems in the Valley remain unsolved.[72]

V, Conclusion -- The Extent of Groundwater Law Changes in California

All users of groundwater -- private, public, overlaying landowners, or non overlaying landowners -- must use groundwater for reasonable purposes under the Correlative Rights Doctrine. When a condition of shortage exists, prescriptive rights may be applied against private users, so all users must pump vigorously in order to protect their rights in the event of an adjudication of those rights. Past groundwater right adjudications have resulted in all groundwater users having their uses curtailed by a "just and fair proportion". Whenever the amounts pumped from an acquifer were in excess of the constant annual supply or safe yield, the right to extract groundwater in total was curtailed to the safe yield, and all individual users shared equally in this curtailment. This procedure establishes quotas to groundwater which create and add the characteristic of exclusion to property rights

[72] Elinor Ostrom, "Collective Action and the Tragedy of the Commons," in Managing the Commons, edited by Garret Hardin and John Baden, San Francisco: W. H. Freeman and Co., 1977. Since individuals in the San Joaquin Valley have access to a wide variety of institutional arrangements for collective action, then it must be that their common pool problem remains unsolved because the benefits of collective action do not exceed the costs of collective action for any presently available decision rule.

in groundwater. In that most adjudications also allow for transfer of the adjudicated rights, the adjudications allow for efficient management of groundwater.

Whenever an individual feels his rights to groundwater are being abused by others, he may petition the court to protect his rights. Court administered management of acquifers has been limited to establishing limits beyond which pumping may not preceed. The costs of this management are decreased availability of groundwater today, but the benefit is lowered extraction costs in the future. To accept court administered management is a collective decision. If such management improves the welfare of groundwater users, meaning the benefits outweigh the costs, then adjudication of groundwater rights is a collectively rational decision. Though adjudication of groundwater rights, and subsequent court administration, has been the main technique of modification of the Correlative Rights Doctrine, other modifications have been made -- the City of Los Angeles has established exclusive ownership over the groundwaters of the San Fernando Valley, and the Orange County Water District has limited access to and use of the groundwaters of the Orange County Basin by use of the district's taxing and spending powers. However, despite severe overdraft problems, the groundwater users of the San Joaquin Valley have decided not to modify the Correlative Rights Doctrine but to suffer the consequences of using groundwater under common property rights.

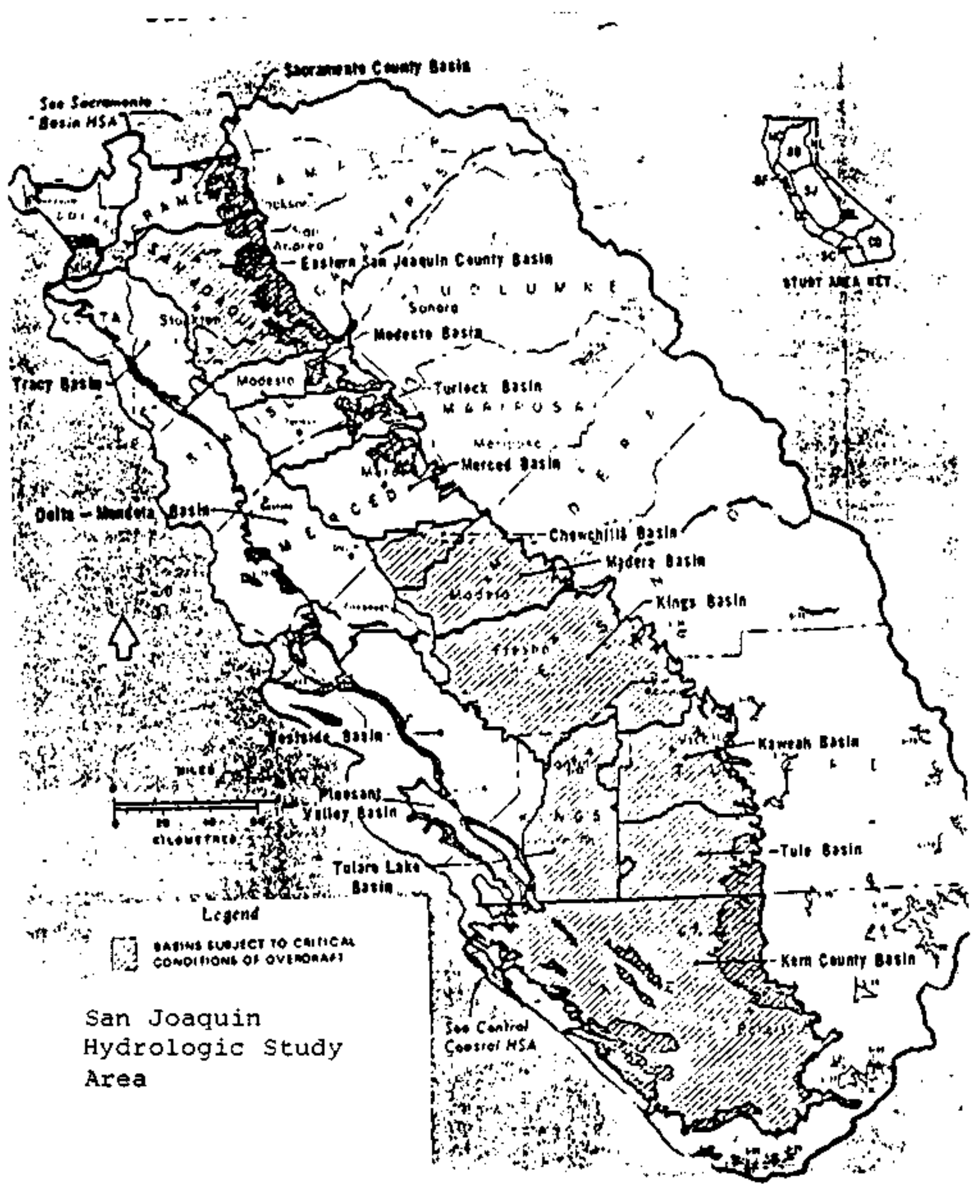
This dissertation attempts to explain why there has evolved, in the state of California, two different property rights institutions governing groundwater use. One system continues the common property rights of the Correlative Rights Doctrine, while the other has modified the Correlative Rights Doctrine by establishing exclusive rights to groundwater. Chapters two and three summarize the history of how the Correlative Rights Doctrine was modified by the City of Los Angeles and by the groundwater users on the South Coast Basin, respectively. Attention is next focused on the San Joaquin Valley. Chapter four quantifies the costs of continuing to use groundwater under common property rights to the groundwater users in the

San Joaquin Valley. Chapter five looks at the past responses from the Valley's groundwater users to overdraft, and chapter six analyzes the institutional constraints to establishing efficient groundwater management through adjudication of groundwater rights in the San Joaquin Valley.

The general conclusion is that though high groundwater costs, due to overdraft, results in an incentive to add exclusion to the list of groundwater's property rights characteristics, the type of behavior motivated by those increasing costs is considerably different. In those areas where groundwater rights were adjudicated, or exclusion was otherwise obtained, groundwater was the cheaper of two sources of additional water, and hence accrued a rent to its owners. Rent-seeking behavior led these groundwater users to protect their rights to groundwater, or to protect the rent earning capacity of the groundwater resource. However, in the San Joaquin Valley, groundwater is the more expensive of two alternative sources of water, and hence, rent-seeking efforts are directed away from groundwater protection and towards obtaining more surface water, since the latter is the cheaper source of water and earns rent to those who employ it.

Figure 1-1

Critically Overdrafted Basins in the
San Joaquin Valley



Source: Calif. Dept. of Water Resources, Bulletin 118-80

CHAPTER TWO

MANAGEMENT OF THE GROUNDWATER RESOURCES OF THE CITY OF LOS ANGELES

I. Groundwater Resources of the San Fernando Valley

The floor of the San Fernando Valley "consists largely of sands and gravels of an absorbent nature, sloping gently towards the Cahuenga Mountains and the narrows of the river at the southeast corner of the Valley. The winter floods of the Sierra Madre are discharged upon these absorbent gravels, where they rapidly sink, forming a great underground reservoir with a sloping water plane. This reservoir discharges with marked regularity through its outlet at the northern and highest part of the-City, the Narrows of the Los Angeles River."[1] As the San Fernando Valley's underground reservoir slopes gently towards the southeast, the hard bedrock under the Narrows of the Los Angeles River (also called the Glendale Narrows) where the Santa Monica Mountains meet the San Gabriel Mountains, forces the water to spill out of the reservoir to the South Coastal Basin below, forming the Los Angeles River (see Figure 2-1).

Discovery of the Los Angeles River by Franciscan missionaries on August 2, 1769 led to the establishment of the City of Los Angeles (El Pueblo de Nuestra Senora la Reina de Los Angeles de Porciuncula) on September 4, 1781 by Governor Felipe de Neve.[2] DeNeve

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[1] Los Angeles Board of Public Service Commissioners, "Introductory Historical Sketch of the Los Angeles Aqueduct," in Complete Report on Construction of the Los Angeles Aqueduct. Los Angeles: Department of Public Service, 1916, p. 32.

[2] Workers of the Writers' Program of the Work Projects Administration in Southern California, Los Angeles: A Guide to the City and Its Environs. New York: Hastings House, 1941, p. 50.

established Los Angeles as a pueblo to produce food for the Alta California garrisons.[3] Without the Los Angeles River there would be no City of Los Angeles, and without the groundwater reservoir underlying the San Fernando Valley, there would be no Los Angeles River. The subterranean bedrock, which rises to within one hundred feet of the surface of the flood plain at the Narrows, forces the water percolating through the porous alluvial fill in the San Fernando Valley to the surface where the Spanish easily diverted the water into ditches for irrigation without advanced technology.[4] The pueblo of Los Angeles was situated so that the northern border of the twenty eight square mile pueblo was bisected by the Los Anglees River.

The Los Angeles River is created by the overflow of water from the San Fernando Valley's underground reservoir. Though it is possible that the water table of the reservoir could fall below the altitude of the Narrows causing the river to cease flowing, normally, the greater the water in the reservoir, the greater the flow of the river. To control the flow of the Los Angeles River, it is necessary to control the amount of water beneath the floor of the San Fernando Valley -- a fact that dominates the history of the water supply system of the City of Los Angeles. The City protected the waters beneath the San Fernando Valley first by exercise of its pueblo rights to water, and later by direct ownership of the valley floor. This chapter chronicles the means by which the City developed and managed the groundwater resources of its water supply system.

Water was the element that determined the location of the pueblo, and the area of the pueblo was adjusted to the available supply.[5] According to Spanish law, pueblos were granted sufficient surface waters to supply the needs of their population and to discharge other

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[3] David Lavender. Los Angeles: Two Hundred, Tulsa: Continental Heritage Press, 1980, p. 167.

[4] Vincent Ostrom. Water and Politics. Los Angeles: The Haynes Foundation, 1953, p. 230.

[5] Los Angeles Board of Public Service Commissioners, p. 31.

responsibilities. When the United States took possession of California, the Treaty of Guadalupe-Hildago (1848) allowed for many of the Spanish-based Mexican laws to be honored, so when the City of Los Angeles wrote its Charter, the "pueblo rights" to water were included. Pueblo rights are not defined in terms of a specific quantity of water, but are open-ended rights defined by the needs of the pueblo. In 1881, the California Supreme Court affirmed that the pueblo rights were granted to the City.[6]

After the transition from Mexican to American governance, the issue of private versus public ownership of the water system became a central issue in the history of the municipality. From the beginning of the pueblo, management of the water distribution system followed the Spanish tradition[7] of public control, though in the American-governed era, strong admixtures of private ownership were made. In 1976, the City's pueblo right and public control was to be expanded by the California Supreme Court to allow the City absolute ownership of the Los Angeles River and of the groundwaters of the San Fernando Valley.

II. Establishing Management by Ownership of the Groundwaters of the San Fernando Basin by the City of Los Angeles.

In 1857, the Los Angeles City Council first experimented with private enterprise in the distribution of water by granting to William G. Dryden a franchise for residential delivery of water from the artesian springs that arose on his property.[8] In 1865 the Los Angeles City Water Company was given a 33 year lease for private management of the City's water system.[9] Under the company's direction, the water distribution system was changed from an

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6 Anastacio Feliz v. City of Los Angeles, 58 C. 73 (1881).

7 See Arthur Maass and Steven Anderson, ... and the Deserts Shall Rejoice: Conflict, Growth, and Justice in Arid Environments, Cambridge, Mass.: The MIT Press, 1978.

8 William L. Kahrl, Water and Power, Berkeley: University of California Press, 1982, p. 8.

9 Ostrom, p.38.

agricultural irrigation network to a modern municipal water system. The water company's supply was from Crystal Springs on the Feliz rancho located immediately above the Narrows.[10] Because the groundwater reservoir beneath the San Fernando Valley was full, pressure was exerted upon the waters, forcing them up through artesian well openings in the ground.[11]

The Crystal Springs were also fed by underground flows from the adjacent Los Angeles River.[12] Though the franchise had restricted the company from diverting much water from the Los Angeles River, to supplement the supply from the springs, the company drove a tunnel under the river to tap the underground flow of the river. During the last years of the lease the company was taking 12 to 15 hundred miners' inches[13] of water under a franchise for a maximum diversion of ten inches.[14] Being a mixture of artesian spring water and water from the underground flow of the Los Angeles River, the waters provided to the City by the Los Angeles City Water Company were predominantly groundwaters. Groundwater dominated the first waters supplied to the City of Los Angeles and groundwater would continue to dominate the history of the City's water supply.

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[10] Ibid., p. 45.

[11] No pumping is required to tap groundwater which flows from an artesian well, only collection and distribution facilities. The pressure of a full aquifer is sufficient to drive the groundwater through a surface opening, but if that pressure is diminished by extraction of more groundwater than enters the basin, the artesian well must be replaced by a pumped well if water is to be taken from the aquifer.

[12] This physical fact was used by the City of Los Angeles to extend to groundwater its pueblo right to surface water in City of Los Angeles v. Pomeroy. 124C. 597, (1899).

[13] The standard unit of water measure used throughout this dissertation is an acre-foot of water. Unfortunately, water has been measured in many different units during California's history, From Jerome Milliman, "History, Organization and Economic Problems of the Metropolitan Water District of Sourthern California," Ph.D. dissertation, University of California, Los Angeles, 1956, the following equivalence is offered to convert one unit of measure into another: 40 miners' inch = 723.795 acre-feet per year = one cubic foot per second. Also, one acre-foot is equivalent to 43,560 cubic feet or 325,850 gallons.

[14] Ostrom, p. 45.

In 1898 the City began negotiations to return the water system to public ownership. During negotiations over the price the City would pay to purchase the company, the City claimed that since the Crystal Springs were fed by underground flows from the adjacent Los Angeles River, it owned the rights to all water in the springs, and therefore would not pay for what it already possessed.[15] To support this claim, a suit was filed by the City of Los Angeles against irrigators who had installed infiltration galleries above the Narrows to capture the subterranean flows of the river.[16] The California Supreme Court thereupon issued the first definitive affirmation of the City of Los Angeles' claims to the groundwater of the Los Angeles River. After four years of negotiation and litigation, the City purchased the distribution lines and equipment for $2,000,000. After re-establishing public ownership, the City immediately made a 63 percent reduction in domestic water rates.[17]

Along with the capital equipment, the city also acquired the services of the superintendent of the company, William Mulholland, who carried the information of "the size of every inch of pipe, the age and location of every valve" in his head.[18] His services proved valuable not only in the transference of ownership and operation of the water system to the City, but also in preventing water shortage from restricting the growth of the city from the state's richest agricultural area to its largest urban metropolis. Municipal take-over for Mulholland meant access to funding for the expansion of and improvements in the system which the tight-fisted private management had refused to support.[19] Mulholland made the

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[15] Kahrl.p. 16.

[16] City of Los Angeles y Pomeroy. 124C. 597. 63 (1899).

[17] Workers of the Writers' Program of the Work Projects Administration in Southern California, p. 51. Another source, J. M. Guinn. A History of California and an Extended History of Its Southern Coast Counties, Los Angeles: Historic Record Co., 1907, p.346, says that the decrease was only 10 percent.

[18] Kahrl.p. 23

[19] Ibid.

most of this opportunity, becoming arguably the most successful if not controversial municipal water manager in the county.

As early as 1903, William Mulholland began augmenting the waters available from the Los Angeles River by completing the Elysian Reservoir, expanding the Buena Vista pumping plant (located immediately below the Narrows), and driving a tunnel into the bedrock beneath the channel of the Los Angeles River. He planned for the city to sink wells into this tunnel and extract the groundwater that percolated into It.[20] In 1905, after ten years of below average rainfall, the City's need for water was so great that the complete surface flow of the Los Angeles River was being diverted. To increase the supply of water, additional wells were constructed, underground galleries in the bed rock were extended across the Narrows into the San Fernando Basin to withdraw the subterranean flow of the river, and wells were put down on the southern side of the City (i.e. into the Coastal Plain) from which water was pumped during the summer months and put directly into the City's water mains.[21] By tapping groundwater sources during times of deficient surface water supply, the City and its Chief Engineer were pioneering a groundwater management system commonly known as conjunctive use.

Given the rapid growth rate in the city's population and the occurrence of periodic drought, the City searched to find additional sources of water. Walter C. Mendenhall, under the direction of the United States Geological Survey, conducted three studies of the underground

[20] Kahrl.p. 25.

[21] Ostrom, p. 9. As the drought continued, an extension of the underground galleries and wells at the Narrows and the sinking of wells into the South Coastal Plain under Mulholland's direction, provided an additional average flow of 28.5 cubic feet per second for the City giving a total supply of 71.5 cubic feet per second. The drought had lowered the yield of the Los Angeles River far below its safe yield of 80 cubic feet per second (which is equivalent to 57,904 acre-feet per year).

waters in the central, eastern and western Coastal Plain regions of southern California.22 Mendenhall estimated that $2,413,000 had been invested in the pumping wells on the Coastal Plain to produce 13,750 miners' inches of water to irrigate 100,000 acres, but, "these studies and opinions regarding the underground waters of the Coastal Plain agreed that in case the City endeavored to obtain an adequate supply for its future requirements from this source, it would have to enter into a contest with all the interests that have become vested in this district, and such a conflict would, if successful, reduce greatly the water supply for a large area tributary to the City."[23] Though groundwater did exist in close proximity to the south of the Pueblo, the City could not gain access to it except at great cost.

To replenish the decreased flows of the Los Angeles River during the drought that occurred in the first decade of the 20th Century, the City of Los Angeles instituted proceedings against more than two hundred ranchers who were irrigating five thousand acres of land near the City of Burbank with water pumped from the aquifer underlying the San Fernando Valley.[24] The California Supreme Court extended to the full underground supply of the San Fernando Valley the prior claim of the City of Los Angeles to the pueblo rights of the Los Angeles River.[25] The City's victory severed the ranchers' access to their wells. The victory provided the City with a means (i.e. public management) to manage the underground reservoir of the San Fernando Valley. By controlling groundwater extractions, and by controlling the level of water in the San Fernando Basin, the City could control the flow of the Los Angeles River. Any withdrawals from the basin could be prevented through the City's claim to pueblo

22 See United States Department of the Interior, United States Geological Service, Water Supply and Irrigation Papers No. 138, 137, and 139, by Walter C. Mendenhall, 1905.

23 Los Angeles Board of Public Service Commissioners, p. 45.

24 Ostrom, p. 35.

25 City of Los Angeles v. Jesse D. Hunter; and City of Los Angeles V. Thomas D. Buffington. 156 C. 603,607(1909).

rights, thus allowing the City to maintain the "safe yield flow" of the Los Angeles River at 80 cubic feet per second.[26] Because the surface flows of the Los Angeles River were already fully developed, this legal victory and exercise of the pueblo right could provide no additional water to the City. Additional water supply required the City to begin operating its own wells in the San Fernando Valley.

As eloquently described in the following quote, the City had knowledge of the common property incentive to extract groundwater, its ability to control extractions from under the San Fernando Valley, and the costs involved in exercising this management option:[27]

> As intensive and profitable agriculture, In this region, is dependent upon the available water supply, and as lands without water have intrinsic values less than one-fourth of those having water, it naturally followed that private parties made encroachments at every possible point upon the water supply of the City. Men on the small farms in the San Fernando Valley, overlying the underground waters of the Los Angeles River, put down wells upon their own lands and pumped therefrom and applied the waters on the lands which they owned. The City was obliged, in order to provide for the necessities of its citizens, to procure injunctions against these intrusions, but enforcement of the orders of the court would be so disastrous to those who had built small homes that it was deemed inexpedient to apply them unless actual water shortages should make such action imperatively necessary although the City had spent $ 150,000 in establishing its rights to this water.

To weather the drought, instead of aggressively using its pueblo rights, the City, under Mulholland's direction, secured an additional average flow of 28.5 cubic feet per second, for a total supply of 71.5 cubic feet per second, through the extension of the underground galleries and wells at the Narrows and the sinking of wells into the South Coastal Plain. Realizing it's indigenous water supply had been stretched nearly to the limit, the City of Los Angeles filed its first notice of appropriation from the Owens River on October 23, 1905.28 The notice of appropriation was the first step in the building of the Los Angeles

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[26] Los Angeles Board of Public Service Commissioners, ibid., p. 35.

[27] Ibid., p. 36.

[28] Kahrl.p. 130.

Aqueduct, capable of bringing 440 cubic feet per second of water from the Owens Valley to the San Fernando Valley. The first claim, for one thousand cubic feet per second of the flow of the Owens River, was made at a point far south of any agricultural activity in the valley to avoid harm to the economic livelihood of the Owens Valley. According to William Kahrl, an authority on the Los Angeles - Owens Valley controversy, "Mulholland intended to operate the project at full capacity from the very beginning for the benefit of agriculture in the San Fernando Valley.... Mulholland's basic conception of the aqueduct depended upon the use of the San Fernando Valley's vast underground reservoirs to store the waters from the Owens Valley and enhance the flows of the Los Angeles River."[29]

Bond issues of 1.5 million dollars for purchase of rights-of-way and 23 million dollars for construction of the aqueduct were approved by the voters of the City of Los Angeles in 1905. It would be eight years before the promised water would be delivered. In the meantime, according to the City's report on the aqueduct's construction, "Because of the series of wet seasons and the resort to the temporary expedient of robbing the agricultural lands of the coastal plain of their ground water, the city escaped a water famine during the period of its wonderful growth (from a population of nearly 200,000 in 1905 to 500,000 in 1913), but there was no margin of safety, and the lowering of the ground water plane confirmed the judgment of the Water Board and its engineers in seeking other sources of supply."[30]

In their report of 1911, the consulting engineers of John Henry Quinton, W. H. Code, and Homer Hamlin estimated that the aqueduct would provide the city with eight times as much water as it could immediately consume, and four times as much as it would ever be able to use

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[29] Kahrl, p. 132. Two things to note in these numbers: the aqueduct would provide a flow of water five and a half times greater that the Los Angeles River, and the original appropriation was for a flow of water 2.27 times greater than the aqueduct's capacity.

[30] Allen Kelly, "Introductory Historical Sketch of the Los Angeles Aqueduct," in Complete Report on Construction of the Los Angeles Aqueduct, by the Los Angeles Board of Public Service Commissioners, Los Angeles: Department of Public Service, 1916, p. 10.

once all the lands within its existing borders were fully developed.[31] To dispose of this surplus water, Quinton, Code and Hamlin called for municipal expansion to include the San Fernando Valley within the City's boundaries. In agreement with Mulholland's plan, they also proposed that 275 cubic feet per second of the surplus be devoted to irrigation in the San Fernando Valley. Since one-fourth of every drop of water used for agriculture in the Valley would enter the vast groundwater reservoir and add to the flow of the Los Angeles River, irrigation would return to the City for subsequent use an additional 80 cubic feet per second, or double the present safe yield of the Los Angeles River.32 OnAugust 29, 1913, "the Public Service Commission formally adopted the Quinton, Code, and Hamlin report as city policy, thereby opening the way to a decade of massive annexations to the City of Los Angeles."[33]

The water from the Owens Valley finally arrived in Los Angeles on November 5, 1913. The water was not brought to Los Angeles, rather Los Angeles had to go to the water.[34] The aqueduct ended in the northeast corner of the San Fernando Valley, which within two years would be almost completely annexed to the City. Residents of the San Fernando Valley formed County Water District No. 3 and approved the issuing of bonds for a distribution system. In order to gain access to the water, the Valley residents (except for the municipalities of San Fernando, Burbank.andGlendale) in March of 1915, voted to join the City of Los Angeles by a vote of 681 to 20.[35] The following May the annexation of 170 square miles of the valley was approved by the voters of Los Angeles, thus doubling the City's si2e from 108 to 278 square

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[31] Kahrl.p. 182. Also see, Los Angeles Board of Water Commissioners. Report Upon the Distribution of the Surplus Waters of the Los Angeles Aqueduct, by John Henry Quinton, W. H. Code, and Homer Hamlin, 1911.
[32] Kahrl, pp. 183-4.
[33] Ibid., p. 226.
[34] Workers of the Writers' Program of the Work Projects Administration in Southern California, p. 51.
[35] Howard J. Nelson. The Los Angeles Metropolis. Dubuque: Kendall/Hunt Publishing Company, 1983, p. 79.

miles. Subsequent additions[36] in 1916 and 1917 brought the city's total land area to more than 350 square miles, a rate of expansion supported entirely by the introduction of aqueduct water.[37]

As explained by Vincent Ostrom in his study on the growth of the City of Los Angeles: "Annexation was the essential prerequisite to the sale of water. The annexation movement of 1915-1927, stimulated by the availability of surplus aqueduct water marked one of the most significant developments in the history of Los Angeles.... This great annexation movement came and passed as a concomitant of the surplus water made available by the aqueduct from Owens Valley. The territorial characteristics of the City of Los Angeles are today largely the product of municipal policies for disposing this surplus water."[38] Though water was needed by all the South Coast Basin, only Los Angeles had gone deeply into debt to acquire it. Two factors effectively blocked any sale of aqueduct water to agencies outside the city limits: President Roosevelt had placed restrictions against the sale of Owens Valley water to wholesalers in granting the right of way for the city's aqueduct across federal land between Los Angeles and Owens Valley,[35] and the city's charter prohibited alienation of any part of the city's water supply without a vote of the people.[40] Therefore, any community wanting to share the benefits of the aqueduct would have to become annexed to the city and assume a portion of the bonded indebtedness.[41]

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36 Such as the Palms area, the Westgate area from Beverly Hills to Santa Monica, and the West Coast area which includes the airport.

37 **Kahrl.p.** 226.

38 Ostrom, p. 157 and p. 159. Italics added.

39 Remi Nadeau. Los Angeles: from Mission to Modern City. New York: Longmans, Green and Co., 1960, p. 164.

40 **Kahrl, p.** 133.

41 Lynn Bowman. Los Angeles: Epic of a City, Berkeley: Howell-North Books, 1974, p. 251.

Expansion of its pueblo rights to groundwater without annexation of the San Fernando Valley could have provided the City with the means for efficient management of the underground reservoir. The pueblo right gave the City exclusive control over extractions from the San Fernando Basin, thus eliminating any common property characteristics of groundwater use. Los Angeles could protect its rights to both the natural waters beneath the San Fernando Valley, as well as the waters imported from the Owens Valley that percolated into the underground reservoir, by claiming that these waters, as the source of the Los Angeles River, were protected by the City's pueblo rights. However, the extent of the City's exclusive control by this means was limited by the costs of repeated adjudication against individual private[42] pumpers who made "encroachments at every possible point upon the water supply of the City".

Rather than resort to adjudication to establish its control over the underground source of the Los Angeles River, the City of Los Angeles chose the less expensive and more effective process of annexation. Nearly complete incorporation of the San Fernando Valley provided the City a means of eliminating competitive pumping from the aquifer. According to Vincent Ostrom ,[43]

> ...the City of Los Angeles was deliberately organized as a unit of government to assure control over San Fernando Valley as the basic hydrologic unit in the upper basin of the Los Angeles River system. In considering the areas to be annexed to Los Angeles as a part of the policies for disposing of the surplus water from the Los Angeles Aqueduct, first priority was given to San Fernando Valley since control over this area would make it possible to re-use irrigation water that percolated into the underground supply and would permit systematic use of the underground storage capacity as a reservoir for surplus water that might be spread upon the gravel cones of the tributary washes. As a result the upper Los Angeles River basin could be managed so as to permit maximum utilization of its water crop and storage potentials with the minimum amount of conflict among competing uses and priorities of use.

[42] Adjudication against large public pumpers such as the cities of Glendale and Burbank and San Fernando were initiated in 1955 and successfully brought to a close in 1979.

[43] Ostrom, p. 233.

III. Extending the Philosophy of Management by Ownership to the Owens Valley

Ten of eleven wells put down in the bottom lands of Owens Valley, land along the line of the aquifer controlled by the City of Los Angeles, had struck artesian water.[44] Initially nothing was done to develop the groundwater potential of the Owens Valley until 1918,[45]

> when the demands of agriculture in the San Fernando Valley compelled the city to begin seeking ways to supplement the flows of the aqueduct during the peak of the irrigation season. Thirty-two wells were sunk in the Owens Valley in 1918, 1919, and 1920, and air compressors were installed to augment the artesian flows at eighteen of these sites in 1919. Even though pumping was necessary for only a few months of the year, these first wells by the end of 1920 had produced nearly twenty-five thousand acre feet for the aqueduct.

The City's water engineer was determined to advance his concept of managing the San Fernando Basin as a storage basin for Owens Valley water. Operation of the aqueduct was dependent ultimately upon using the Owens Valley groundwater basin for storage in wet years and as a supplemental source of supply for the City in periods of drought. This vision contributed to Mulholland's original tolerance toward the development of Owens Valley agriculture, and it had later inspired his war with the Valley at a time when he believed the city's need demanded complete control of the valley's most productive pumping fields.[46] According to William Kahrl:[47]

> With this perception that groundwater reservoirs could be used not simply as a supplemental source of supply but more importantly as a far superior substitute for surface storage, Mulholland intuitively grasped the basic elements of a concept for the coordinated development of surface and groundwater resources. It was an idea well in advance of its time.... But it was this central idea which animated Mulholland's vision of how the aqueduct could be operated as a link between the great groundwater reservoirs of the Owens and San Fernando valleys.

[44] Kelly, p. 25.

[45] Kahrl, p. 254.

[46] Ibid., p. 400.

[47] Ibid., p. 253.

Because of low water prices which encouraged irrigation, irrigated acreage in the San Fernando Valley expanded from 3000 acres in 1914 to a peak in 1920 of 80,000. The basins groundwater table regained its maximum level in 1922, supported in part by the return flows from irrigation water -- water provided by the aqueduct. In 1923, however, precipitation in Los Angeles dropped to less than half of normal in a repeat of the dry cycle at the turn of the century, and meanwhile the population of Los Angeles was doubling in just five years between 1920 and 1925. Surplus had turned to deficiency and from deficiency to crisis.

The City of Los Angeles quickly absorbed its earlier water surplus because World War I demands for foodstuffs had accelerated the growth of irrigation in the San Fernando Valley, and because of post-war population increases. Again, the City needed more water. Though the aqueduct was designed to carry 440 cubic feet per second, by 1920 it delivered a mean annual flow of only 260 cubic feet per second, or only 60 percent of its capacity. Since the waters of the Owens River were completely appropriated for the aqueduct, only the groundwater of the Owens Valley was an available additional source of water for the City. Groundwater pumping in the Owens Valley would increase the volume of water flowing through the Los Angeles Aqueduct, increase the water available for irrigation in the San Fernando Valley, and increase the waters flowing in the Los Angeles River.

To cope with the drought of the 1920's, pumping in the Los Angeles River area was abruptly renewed, with the result that groundwater levels which had risen over twenty feet by 1922, began to drop fifteen to fifty feet over the next three years.[48] Recognizing that its water demands had again exceeded the amount of water available, the City now turned to an untapped, though far-distant new source of water. In June of 1924 William Mulholiand formally filed for fifteen hundred cubic feet per second of water from the Colorado River. Furthermore, in 1927 the Water and Power Commission put an end to the 12 year annexation

[48] Ibid., p. 260.

movement by "requesting that no more territory be annexed to the city until a new source of water could be made available."[49] Nonetheless, the most dramatic consequence of the drought of the 1920's occurred in the Owens Valley.

Beginning in 1923, the Department of Water and Power authorized the acquisition of land and water rights previously left in the hands of local residents in central and northern Owens Valley "to divert water used there for irrigation into the aqueduct and to enable the city to tap the underground supply with wells."[50] By 1926, the City owned *or* was negotiating for 90 percent of all the land and water rights on the Owens River: and by 1933 it had captured 95 percent of all farmlands and 85 percent of the town properties in the Owens Valley.[51] Since any riparian landowner can object to an appropriation of surface water if the appropriation harms the landowner's riparian rights, the City eliminated its rivals to this water by becoming the sole riparian landowner along the Owens River. Ownership of the lands along the Owens River allowed the City to appropriate the waters of the river because, since the City held the riparian rights to the waters, no one remained to challenge its right to appropriate the river.

Similarly, the City also needed to own the lands overlying the aquifer if it desired to appropriate the groundwater. Since only the owner of the lands overlying the groundwater basin has the right to extract groundwater, or to prevent the use of groundwater on non-overlying lands, ownership of the lands overlying the Owens Valley Basin likewise eliminated any rivale to the City's right to pump groundwater into the aqueduct. The 1921 case of City of San Bernardino v. City of Riverside et al.[52] established that the overlying landowners had exclusive rights to the groundwater (as riparian landowners have rights to the surface

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49 Ostrom, p. 159.

50 Ibid., p. 62.

51 Kahrl.p. 301 and p. 314.

52 Citv of San Bernardino y. City of Riverside et al.. 186 C. 7, 198 P. 784(1921).

water), and that these overlying landowners could prevent the appropriation of the groundwater for use on nonoverlying lands. Appropriation of groundwater that changed "the place or character of the use" (i.e. from the Owens Valley to the San Fernando Valley) is possible only "provided others are not injured by the change." To gain a right to appropriate the groundwaters of the Owens Valley, it was necessary for the City to purchase the lands, and by becoming the sole overlying landowner, no one was injured by, or could object to, the appropriation of water.

The City sought title to the land of the Owens Valley to gain access to its groundwater. This was why, already owning the southern part of the valley, the City had begun to extend its ownership towards the north. However, unlike annexation of the San Fernando Valley, which only involved extension of the City's political authority, purchase of the Owens Valley -- its farms, businesses, and homes -- proved much more difficult. It was the purchase of Owens Valley land for its groundwater that led to the tensions that exploded into the "Owens Valley War" of the 1920's, and extraction of the groundwater would precipitate the "second war of the Owens Valley"[53] in the 1960's.

Between 1923 and 1926, Mulholland installed 52 new wells which had a maximum pumpage rate of 325 cubic feet per second, to the Independence region of the Owens Valley.[54] By 1930, Los Angeles had drilled a total of 171 wells in the Owens Valley.[55] In just four years, from 1929 through 1932, Los Angeles extracted an estimated 336,000 acre-feet from the groundwater reservoirs around Bishop and Independence. And by 1931 the city's wells in the valley were producing fully 30 percent of the total aqueduct supply. The Department of

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[53] Kahrl, p. 416.

[54] Ibid., p. 286. The production of the wells is near the capacity of the aqueduct and greater than the quantity delivered through it in 1920. The Western Construction News of October 25, 1926 noted that Los Angeles was operating the second largest groundwater management project in the United States.

[55] Kahrl.p. 285.

Water and Power's bond issue of 1930, which provided funds to complete the acquisition of the valley, was endorsed by the Los Angeles Times, In part, on the grounds that "Unchallenged control of these underground water resources requires the ownership by the city of all lands and water rights of every nature within the confines of the valley."[56]

Though ownership of the Owens Valley and control over its groundwaters was nearly complete, the time had not yet come for the Los Angeles Aqueduct to became a siphon between the Owens Valley aquifer and the San Fernando Valley aquifer. After 1932 the Department of Water and Power all but stopped pumping in the valley. Cessation of extraction allowed groundwater to build up in the basin so that by 1935 the artesian wells first observed by the United States Geological Survey in 1906 were flowing freely once again. The City's action seemed at the time to offer a means of achieving a speedy settlement of the extensive litigation that had been prompted by the operation of the city's wells on lands formerly owned by the Hillside Water Company.[57] Furthermore, since precipitation had returned to normal, the flow of the Owens River was sufficient to fill the aqueduct, and since an extension of the aqueduct northward to the Mono Basin promised additional water which would cost less than the cost of groundwater litigation, the wells were to be left idle.[58]

Groundwater extractions in the thirty years from 1933 to 1963 dropped to an annual average of only ten cubic feet per second -- about 2.3 percent (down from a high of 30 percent) of the total aqueduct supply. The Mono Basin extension was completed at the end of 1940, and its completion allowed the Los Angeles Aqueduct to achieve full utilization of the

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[56] Ibid., p. 401, from the Los Angeles Times, March 16,1930.

[57] Hillside Water Company v. City of Los Angeles. 10 C. 2d 677 (1938). and Hillside Water Company v. City of Los Angeles. Inyo County Superior Court, No. 2073. Ranchers on lands formerly owned by the Hillside Water Company were originally granted an injunction to protect their water rights, but the State Supreme Court overturned this injunction granting the ranchers damages instead. The City, however, ceased further pumping rather than being troubled with calculating the value of the damages. See Kahrl, p. 402.

[58] Kahrl, p. 401.

total capacity for the first time in 1946. By 1948 Los Angeles maintained 110 wells in the Owens Valley, but their combined pumping capacity was only three hundred cubic feet per second -- capacity which the Department of Water and Power asserted would not be used unless there was a severe drought.[59]

IV. Extending the Philosophy of Management by Ownership to the San Fernando Valley

The City's rate of growth and geographic development was conditioned by its available water supplies. The City's future water supply was assured by the purchase of most of the Owens Valley, by extension of the Los Angeles Aqueduct to the Mono Basin, and by being a charter member of the Metropolitan Water District which was formed in 1927 to deliver water from the Colorado River to the South Coast Basin. The tremendous growth in the City of Los Angeles following the Second World War put renewed pressures upon the City's water supplies. Increased reliance on Colorado River water was inevitable, but since water purchased from the Metropolitan Water District was the most expensive of alternative supplies, it behooved the City to maximize its use of water from other sources. By 1955, due to deliveries by the Los Angeles Aqueduct and to Metropolitan Water District imports, the safe yield of the Los Angeles River was up to one hundred cubic feet per second. From the point of view of the Department of Water and Power, this cheapest of local supplies "might be increased by another fifty cubic feet per second by eliminating all other diversions by other municipalities such as Glendale, Burbank, and San Fernando and irrigators using private wells..."[60] The only way to eliminate these diversions was for the City to sue these offending cities, as they did in 1955, by claiming the City's pueblo rights extended to the waters the municipalities and irrigators were pumping.

59 Ibid., p. 402.
60 Ostrom, p. 22.

When the San Fernando Valley became part of the City of Los Angeles, the cities of Burbank, Glendale, and San Fernando maintained their political independence. Deliveries of water by the Los Angeles Aqueduct to the San Fernando Valley maintained the water table of the underground reservoir at a high altitude. This high water table increased the flow of the Los Angeles River and lowered the cost of pumping to all wells in the San Fernando Valley, including those wells operated by the cities of Burbank, Glendale, and San Fernando. These cities were receiving advantages from a high water table without having shared the cost of the aqueduct or of its water. In addition, they were pumping water which the City of Los Angeles claimed as its own. The naturally occurring waters in the underground reservoir had been granted to the city as part of its pueblo rights. However, its rights to the aqueduct water which was used for irrigation, and percolated into the reservoir, were less clear since no court precedent had been set.

The case of City of Pasadena y. City of Alhambra et al.[61] had made it possible for a public body to gain a right to groundwater through adverse possession. Under the principle of adverse possession, if the titled owner of a property suffers damage to his property by the actual, continuous, notorious, and hostile possession by a claimant for a statutory period of time in such a way that the titled owner, without actual notice of such possession, may be legally presumed to have notice of the actions of the claimant, then the claimant is granted actual possession and right over the property.[62] Recognizing that the City had established ownership claims to the groundwater of the San Fernando Valley, the cities of Burbank, Glendale, and San Fernando claimed a right to the waters under the San Fernando Valley on the grounds that they had established adverse possession.

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61 City of Pasadena y. City of Alhamhra et al. 33 C. 2d 908, 207 P. 2d 17, (1949).

62 Steven H. Gifis. Law Dictionary. Woodbury. Barron's Educational Series, Inc., 1984 See "notorious possession" p. 318.

As explained in chapter one, the purpose of the principle of adverse possession, legally, is to facilitate the transfer of resources to their highest and best use. [63] if the titled owner takes no action to protect his property from use by another, then it is assumed the adverse claimant values the property higher than the titled owner. However, the establishment of open, notorious, and adverse use for a sufficient amount of time is what grants adverse possession, and not the claim of a more beneficial use. Since adverse possession is such an important source of groundwater rights, a digression to the case of City of Pasadena v. City of Alhambra et al. is warranted.

Overdraft, the pumping of groundwater in excess of the "average constant supply," was a problem in the Raymond Basin, over which sits the cities of Alhambra and Pasadena. The overdraft was so severe (i.e. actual, continuous, notorious, and hostile) and had persisted for such a long time, that in his ruling in City of Pasadena v. City of Alhambra et al.. Chief 'Justice Gibson declared all parties had gained adverse possession to the quantity of water which they had pumped over the previous five years. The burden of curtailing the overdraft was placed on all parties in the proportion to which their newly established rights were a percentage of the total safe yield of the aquifer. Each party's "decreed right" to the groundwater was set at approximately two-thirds of the amount to which it had gained adverse possession.

The court enjoined all pumping in excess of the decreed right and appointed a "watermaster" to enforce the judgment. Though there was no legal precedent for the Chief Justice's ruling and its subsequent administrative procedures, he explained his actions by saying, "Moreover, it seems probable that the solution adopted... will promote the best interests of the public, because a pro tanto reduction of the amount of water devoted to each

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63 Henry Ballantine, "Title by Adverse Possession," Harvard Law Review 32, 1918. p. 135.

present use would normally be less disruptive than total elimination of some of the uses."[64] Though the ruling may have caused minimal disruption in this one basin, it caused a "race to the well-pump" over the next thirty years in other basins of the South Coastal Plain. Municipalities and water companies sought to pump and use as much water as they could in the event that a similar ruling would restrict their future pumping rights to some percentage of the current amount actually pumped.

Such was the legal environment in which Burbank, Glendale, and San Fernando found themselves when their populations began to mushroom after the Second World War. Though water from the Municipal Water District was available, pumping from the San Fernando Valley's groundwater reservoir was a less expensive alternative. So they pumped as much water as they could in order to establish a right by adverse possession to as much groundwater as possible. In 1955 the City of Los Angeles responded by suing the cities of Burbank, Glendale, and San Fernando to quiet its claim to the waters underlying the San Fernando Valley. Thirteen years later, a lower court ruled in favor of the defendants, forcing the City of Los Angeles to lower its rate of pumping from 107 cubic feet per second in 1968 to 72 cubic feet per second in 1969. This groundwater shortfall of supply was balanced by an increase of 7 cubic feet per second from the Los Angeles Aqueduct and the purchase of an additional 21 cubic feet per second from the Metropolitan Water District.

The City of Los Angeles appealed the lower court's decision, but it was not until May 12,1975 that the Supreme Court of the State of California ruled in favor of the City of Los Angeles. The legal victory was greatly valued for its contribution to the City's groundwater

[64] City of Pasadena y. City of Alhambra et al.. 53 C. 2d 908, 207 P. at 32, (1949).

management program.[65] The State Supreme Court reaffirmed the City's pueblo rights, and ruled that the City has paramount rights not only to natural waters in the Upper Los Angeles River area but also to certain return waters in the San Fernando Groundwater Basin. These return waters originate either in the Owens Valley (brought to the San Fernando Valley by the Los Angeles Aqueduct) or are from the Colorado River (purchased by the City from the Metropolitan Water District). The practical effect of the decision was to increase the City's share of water pumped from the San Fernando Basin, and to reduce the amount of more expensive water the City would have to purchase from the MWD.[66]

In City of Los Angeles y. City of San Fernando [67] California's supreme court found that since the City of Los Angeles was importing water, and since the cities of Glendale and Burbank were importing water (from the Colorado River through the Metropolitan Water District), these imports and return flows created a surplus of water over the "average annual supply" of the basin in its natural condition. The court ruled that an overdraft occurs only if "extractions from the basin exceed its safe yield plus any temporary surplus," and that the occurrence of even one surplus year "breaks the continuity required for the running of a prescriptive period." Because a surplus existed, use by the defendant cities could not be considered notorious nor harmful to the plaintiff, hence no adverse possession was established

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65 Pumping from the San Fernando Valley subsequently increased from 113.8 cubic feet per second in 1975 to 162.8 cubic feet per second in 1976, an increase of 30 percent. Though the amount of groundwater pumping in 1976 was only 3.4 cubic feet per second lower than in 1968, the percentage of the total water supply fulfilled by groundwater had dropped from 22 percent in 1968 to 19 percent in 1975. Between the time of the appeal and the final Supreme Court decision, the "second barrel" of the Los Angeles Aqueduct had begun operation, causing a decrease in the percentage of the total water use supplied by the same quantity of San Fernando Valley groundwater. The Los Angeles Aqueduct supplied 60.7 percent of all the water used in Los Angeles in 1970, but by 1973 it supplied 80.3 percent.

66 Los Angeles Board of Water and Power Commissioners, Water and Power Seventy Fourth Annual Report 1974-1975. Los Angeles: Department of Water and Power, 1975, p. 6.

67 City of Los Angeles y. City of San Fernando 123 C. 3d 1,(1975).

by defendants.[68] However, the court did reserve the right to control the amounts of water pumped by all parties to the suit, though "the competing rights are all other than prescriptive in nature." The amounts each city is allowed to pump is limited so as to avoid an overdraft, but these quotas are adjusted for the amounts brought into the basin from all outside sources.

This case completed the City's ownership over the San Fernando Valley's supply of groundwater, and it ceased withdrawals, uncontrolled by the City, from the aquifer. However, the amount of water available from the underground reservoir is limited to within very narrow bounds. As the City continues to grow, so will its demand for water. This demand must be met by waters brought to the City from outside the city limits. As additional supplies are imported, the percentage of the total supplies provided by the groundwaters of the San Fernando Valley will decrease. However, because the imported supplies, gathered and transported from further and further distances, will be more expensive than existing water supplies, groundwater's rent-earning capacity (i.e. its value to the City) will increase.[69] Hence, groundwater's continued efficient management becomes more important. Due to its almost complete ownership of the groundwater resources of the San Fernando Valley, ownership which is based on its pueblo rights, the City has the institutional tools necessary for efficient management of its groundwater resources.

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[68] Along with confirmation of the City's water rights there was a judgment in January 1979 for damages based on a settlement agreement. Burbank and Glendale each agreed to pay Los Angeles about $3 million over the next 10 years, interest free, and seven private defendants were required to pay the City a total of nearly $300,000.

[69] Groundwater's rent-earning capacity is because groundwater's per unit cost is below the per unit cost of alternative water supplies. Use of an acre foot of groundwater foregoes the need to use a unit of the more expensive alternative, The difference between the cost per unit of groundwater and of the alternative is the rent per unit that accrues to a groundwater user. The total value to the City of its groundwater is the multiple of the rent per unit and the total quantity of groundwater used.

V. Challenges to the City's Management by Ownership Philosophy

Because intensive development of the Mono Basin and increased pumping in the Owens Valley was seen as the best prospects for obtaining two hundred and ten cubic feet per second of additional, high quality water at the lowest price, the Board of Water and Power Commissioners in July of 1963 authorized its engineers to begin on the "second barrel of Mulholland's aqueduct to Owens Valley. "[70] Furthermore, the Second Aqueduct was a way for the City to reestablish its independence from the Metropolitan Water District by substituting the cheaper Owens Valley water for MWD water. By 1963 the City was obtaining 14 percent of its supply from the MWD, and by 1970 this percentage reached Its maximum of 25.1 percent. The year following the completion of the second Aqueduct, the City's water supply provided by the MWD had fallen to 9 percent.

The second barrel provided an additional 210 cubic feet per second of water to the City, with more than three-fourths of the total capacity derived from increased pumping in the Owens Valley (increases which would require reductions in local irrigation)."[71] The Los Angeles Aqueduct would be used as a siphon to draw water from below the Owens Valley and deliver it to the San Fernando Valley. In 197O,groundwater pumping from the Owens Valley accounted for 140 cubic feet per second of the Los Angeles Aqueduct's supply, and by 1972 the City was pumping at a rate of 200 cubic feet per second.[72]

To counteract the effects that Increased groundwater pumping had on local agriculture, Inyo County, on November 15,1972, began a decade long court battle with the City of Los Angeles over groundwater pumping in the Owens Valley. Inyo County filed suit under the

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[70] Kahrl.p. 405.

[71] Ibid., p. 410. Groundwater was originally planned to provide a long-term average of 89 cubic feet per second.

[72] Ibid., p. 411.

California Environmental Quality Act of 1970 contending that the city should be required to assess the environmental effects of its pumping program before any further extractions from the valley's groundwater basin were permitted.[73] Subsequent environmental impact statements by the City of Los Angeles in 1974, 1976, and 1978 were repeatedly challenged as inadequate by Inyo County.[74] In the meantime, the City Increased US rate of pumping throughout the decade beyond the 89 cubic feet per second limit imposed in 1972 by the Third District Court of Appeal in Sacramento in response to the Inyo County suit. In 1974 Los Angeles was allowed by the court to pump 221 cubic feet per second, and in 1975 It was granted an appeal for 178 cubic feet per second. In August of 1976 the City's pumping rate was cut back to 149 cubic feet per second, but it was granted a request for a pumping rate of 315 cubic feet per second from July of 1977 through March of 1978 to replace supplies lost from the State Water Project during the severe drought of 1976-77.[75]

On the November 1980 ballot, the citizens of Inyo County endorsed an ordinance, put on the ballot by the Inyo County Board of Supervisors, authorizing the creation of a commission with the power to regulate groundwater extractions within the Owens Valley basin.[76] Despite repeated victories in the court, which had allowed increases in their rate of pumping, the City of Los Angeles faced loss of control over groundwater pumping in the Owens Valley. Inyo County was attempting to gain a voice in a groundwater management program which had direct effects upon the county's environmental and economic future. However, the City interpreted the ordinance as an attempt to prevent its access to the underground water. According to William Kahrl, "What is at stake instead is the freedom the city has enjoyed to draw upon the

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[73] Ibid., p. 416. Also see County of Inyo y. Yorty. 32 C. 3d 795, (1973).

[74] See County of Invo v City of los Angeles. 71 C. 3d 185(1977), find County of Inyo V. City of Los Angeles, 78, C. 3d 82 (1978).

[75] See Kahrl, p. 418-23.

[76] Ibid., p. 428.

supplies at Its disposal in whatever manner it considers most efficient from the point of view of Its citizens. ...Inyo's continuing demands for a wider consideration of alternatives to the city's pumping program in connection with its environmental suit created the possibility for outside interference with the management of the city's water program on an order never before attempted."[77]

More devastating to the operation of the Second Aqueduct than Inyo County's challenge to the groundwater pumping program, was the challenge to the City's right to the waters that flowed into Mono Lake. National Audubon Society et al. v. Superior Court of Alpine County, et al. [78] enjoined the City of Los Angeles from appropriating waters necessary to maintain the level of Mono Lake. The value of the water for this environmental use was deemed superior to the value of the water for domestic purposes. Under the public trust doctrine which applied in this case, the Supreme Court gave the State Water Resources Control Board the power to consider environmental uses when allocating water among competing reasonable uses. By decreasing the Mono Basin supplies available to the Second Aqueduct, the Supreme Court added fuel to the fire raging over the groundwater extractions by the City of Los Angeles from the Owens Valley.

Despite threats to the City of Los Angeles' control over its groundwater supplies in the Owens Valley, the City nevertheless continues to manage the Los Angeles Aqueduct as a siphon between the Owens Valley aquifer and the San Fernando Valley groundwater reservoir. Groundwater pumping from the Owens Valley will be Increased to replace the waters lost from the Mono Lake basin. Because the City owns 95 percent of the Valley, the City will maintain its independence despite the Valley's attempt to gain a say in how much water is extracted. This

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[77] Ibid., p. 435.

[78] National Audubon Society et al. v. Superior Court of Alpine County, et al. 189 C. 3d 346, 33 C. 3d 419 (1983).

independence will allow exercise, according to William Kahrl, of the management strategies of the Department of Water and Power which are "designed to achieve the greatest possible efficiency in the use of the water resources at its disposal. In pursuit of this objective, the department has sought to ward off interference with the administration of its land and water rights in the Owens Valley.... The modern relationship between Los Angeles and the Owens Valley has consequently been shaped by the city's continuing struggle to preserve its independence of action from the growing mutualism and interdependence which characterize water development in the rest of California today."[79]

VI. Operation of the Groundwater Management Program

The City of Los Angeles has a complex yet well managed water supply system. It uses surface water from the Los Angeles River, the Owens River, and the Colorado River, and it uses groundwater from the basins below the Owens Valley and the San Fernando Valley. Table 2-1, found at the end of the chapter, shows the percentages and amounts of water used by the City of Los Angeles by source of supply for selected years. This table categorizes the three sources of supply as the Los Angeles Aqueduct, local wells (including wells that tap the Los Angeles River), and the Metropolitan Water District. These figures from the Department of Water and Power seem to suggest that groundwater is responsible for no more than 23 percent of the City's water needs in any year from 1960 to 1979. However, these figures understate the importance of groundwater to the City of Los Angeles.

When the underground waters of the Owens Valley are separated from the deliveries of the Los Angeles Aqueduct and included with local groundwater supplies, the percentage of total water needs supplied by groundwater increase substantially. In 1977, for example, local groundwater supplied 23 percent of the City's needs and the 333.2 cubic feet per second from

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[79] Kahrl, p. 376.

the Los Angeles Aqueduct was 58 percent of the total supply. However, because 115 cubic feet per second was being pumped from the Owens Valley, the actual groundwater use in the City was 247.2 cubic feet per second, or 43 percent of the total water supply. In 1986, local plus Owens Valley groundwater accounted for 29 percent of the water used in the City of Los Angeles. These percentages of use are yearly averages, but given month-to-month variation, groundwater use in the summer months will be a higher percentage of total water use and during the winter months a lower percentage than the yearly average.

The value of groundwater to the City of Los Angeles is even greater than what the above percentages suggest when one realizes that beyond the average supplies available to the City, the marginal supplies -- those which can be called upon during periods of greatest need -- are almost exclusively groundwater. In any given year the amount of water demanded in Los Angeles is relatively fixed. Given a fixed rate structure and the expected amount of use, the Department knows its operating revenues for any time period (year or season of the year). The department will attempt to supply the amount of water demanded by using the cheapest source available. In a wet year (rainfall above normal) the department will be able to cut back purchases from its most expensive alternative source of water -- the MWD. On the other hand, in a drought year (substantially below-normal rainfall) groundwater pumping in the Owens Valley will be brought on line first, and only as a last resort will additional MWD supplies are purchased.

To track the groundwater management cycle in the Owens Valley, and to show how the management cycle coincides with the weather cycle, the following quotations are taken from the Department of Water and Power's Annual Reports:

1960 -- "To conserve water and assure the continued capacity flows of the Los Angeles Owens River Aqueduct, irrigation was curtailed on Department-owned lands in the Owens - Mono basins which are leased to agricultural users, chiefly for cattle grazing. To draw upon the underground supply and maintain the aqueduct flow at capacity, 20 to 40 deep wells in the Owens Valley were reactivated." [80]

1962 -- "With improved water supply, the Water System discontinued operation of all but four of 68 wells in the Owens Valley which had helped maintain the flow of the Los Angeles Aqueduct during the proceeding drought period."[81]

1964 -- "For the period, April to September, 1964 a 56% of normal runoff was forecast. Following normal practice, some of the Owens Valley pumps were activated to withdraw water from underground storage, thus maintaining a full aqueduct flow. "[82]

1967 -- "As a result of the unusually heavy snowfall of the 1966-67 winter, a runoff of 1761 of the 52-year average was forecast for the Aqueduct's watershed.... This assured ample water to maintain capacity aqueduct flow and made possible extensive water spreading to replenish groundwater basins in the Owens Valley."[83]

In short, when surface supplies are below normal, groundwater pumping increases; when surface supplies are adequate to run the aqueduct at capacity, groundwater pumping is curtailed; and when excess surface water is available, the groundwater aquifer is replenished by spreading water on overlying lands.

As for the San Fernando Valley groundwater reservoir, It too is subject to intensive management. Because local rainfall has become such a small portion of the inflows into the aquifer, and because the total inflows are predictable with relative precision, there is little

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80 Los Angeles Board of Water and Power Commissioners, Water and Power Fifty Ninth Annual Report 1959-1960, Los Angeles: Department of Water and Power, 1960, p. 6.

81 Los Angeles Board of Water and Power Commissioners, Water and Power Sixty First Annual Report 1961-1962, Los Angeles: Department of Water and Power, 1962, p. 6.

82 Los Angeles Board of Water and Power Commissioners, Water and Power Sixty Third Annual Report 1963-1964, Los Angeles: Department of Water and Power, 1964, p, 6.

83 Los Angeles Board of Water and Power Commissioners, Water and Power Sixty Sixth Annual Report 1966-1967, Los Angeles: Department of Water and Power, 1967, p. 9.

variability in the amounts pumped from the aquifer. Nevertheless, the water underlying the San Fernando Valley provides valuable Insurance against adverse conditions as reported in the following Annual Reports:

1971 — "New wells (in the Upper Los Angeles River area) are being completed or developed throughout the system. In addition, a number of capped wells were redeveloped and placed in service. Approximately 399 acre feet of imported water was transferred to the Tujunga Spreading Grounds in the San Fernando Valley and 1,598 acre feet of DWP aqueduct water (released from lower Van Norman Reservoir during the drawdown after the earthquake) was diverted into the Headworks Spreading Grounds adjacent to Griffith Park."[84]

1977 -- "Because of the extremely low precipitation in the Owens Valley and Mono Basin watersheds and the court-imposed injunction limiting groundwater pumping on City lands in the Owens Valley, the Los Angeles Aqueducts delivered only 58% ... of the City's water requirements for the year. Local groundwater wells in the Upper Los Angeles River Basin and other local groundwater basins were pumped above normal to provide the City with ... *23%* of the City's total demand. To protect the basins, over-pumping must be repaid in subsequent wet years by water spreading and/or reduced pumping."[85]

VII. Summary and Conclusion

Groundwater's importance to the City of Los Angeles should not be underestimated. Not only is the water supply system of the City of Los Angeles dominated by groundwater, but the location of the City was determined by the constant overflow from the aquifer underlying the

[84] Los Angeles Board of Water and Power Commissioners, Water and Power Seventh Annual Report 1970-1971, Los Angeles: Department of Water and Power, 1971, p. 7.

[85] Los Angeles Board of Water and Power Commissioners, Water and Power Seventy Sixth Annual Report 1976-1977. Los Angeles: Department of Water and Power, 1977, p. 7.

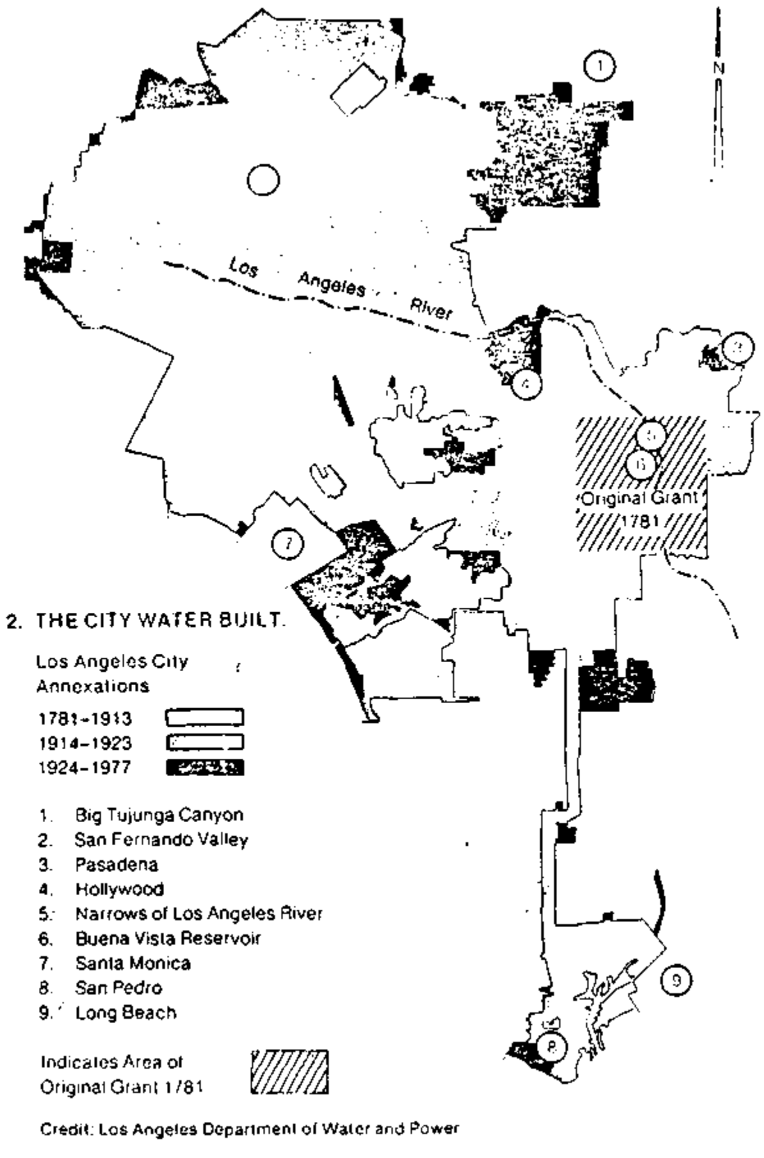
San Fernando Valley. The pattern of growth and the shape of the City were determined by the City's desire to control the flow of the Los Angeles River through management of the underground reservoir beneath the floor of the San Fernando Valley. And some of the most interesting and important events in the history of California's water law are tied to the groundwater management policy of the City of Los Angeles, i.e. management by land ownership.

As explained in the first chapter, groundwater's physical nature and the human laws governing access to groundwater cause competing users of groundwater to impose social costs upon one another. Single ownership of a groundwater aquifer is one means of eliminating these social costs, because competition from other users is eliminated. The City of Los Angeles, being located in an arid environment, saw access to water as a means of survival and growth. Control over water gave the City control over its future. Without water there would be have been no future.

The Los Angeles Aqueduct transfuses the City of Los Angeles with water from the Owens Valley. When the aqueduct was first built, the San Fernando Valley was used to store the delivered water so that it could be collected through the Los Angeles River. When the City needed more water, it turned to the groundwater resources of the Owens Valley. The Los Angeles Aqueduct allows the City to draw upon Owens Valley groundwater in times of water shortage, and in times of plenty, surplus water is diverted to the aquifer for use during the next dry cycle. Such a groundwater management program is possible because only the City owns the groundwaters of the two valleys; no one is able to compete with it for use of these groundwater supplies.

Figure 2-1

Location of the City of Los Angeles and the Los Angeles River



Source: Kahrl, Water and Power

Table 2-1

Water Supply Sources for the City of Los Angeses
(1,000 Acre-feet)

Year	1986	1980	1977
Supply Source			
Local Wells	104.6	75.8	132.2
Los Angeles Aqueduct	486.4	495.2	333.2
Owens Valley Wells	92.3	103	115
Metropolitan Water District	89.7	21.1	108.7
Total	680.7	592.1	574.2

Source: Los Angeles Department of Water and Power

CHAPTER THREE

BUILDING A BETTER MOUSETRAP — THE STORY OF GROUNDWATER MANAGEMENT ON THE SOUTH COASTAL PLAIN

I. Introduction

I. A. The South Coastal Plain

California's Department of Water Resources has divided the state into nine Hydrologic Study Areas for the purpose of identifying and studying its groundwater basins (See Figure 3-1). The South Coastal Hydrologic Study Area (SCHSA), containing portions of Ventura, Los Angeles, Orange, San Bernardino, Riverside, and San Diego counties, has more than 60 groundwater basins.[1] Because the emphasis of this dissertation is on the economic and institutional aspects of groundwater management, only the following managed basins of the SCHSA will be studied: the West Coast Basin, the Central Basin (separated from the West Coast Basin by the Newport-Inglewood Uplift), the Main San Gabriel Valley Basin (separated from the Central Basin by the Whittier Narrows) which are all located along the San Gabriel River; and the Orange County Basin, and the Chino Basin which are located along the Santa Ana River (See Figure 1 -2 for the location of these basins). These five basins are located on what is called the South Coastal Plain - that portion of Los Angeles, Orange, San Bernardino, and Riverside counties lying south of the San Gabriel Mountains and east of the San Bernardino

[1] The following chapter will concentrate on the intensively managed basins of the SCHSA designated by Department of Water Resources by the following basin numbers and names: Basin no. 4-11, the Coastal Plain of Los Angeles, which contains the West Coast Basin and the Central Basin; Basin no. 4-13, the San Gabriel Valley, which contains the Main San Gabriel Valley Basin; Basin no. 8-1, the Coastal Plain of Orange County which contains the Orange County Basin; and Basin no. 8-2, the Upper Santa Ana Valley which contains the Chino Basin.

Mountains. The general shape of this area, also called the Los Angeles Metropolitan area, resembles a triangle which stretches from the Pacific Ocean near Santa Monica east to San Bernardino, and from San Bernardino southwest to Irvine.

Rapid rates of population growth In this area after the Second World War were accompanied by rapid rates of growth in water demand. People living on the lands overlying the West Coast, Central, Main San Gabriel, Orange County, and Chino basins, were relying exclusively on groundwater to meet their water needs. This reliance caused overdraft of these basins and increases in groundwater pumping costs. To meet the area's growing water demands, water was imported from the Colorado River by the Metropolitan Water District beginning in the 1940's. However the quantity of imported water used remained small until extraction of groundwater from the local basins came under local management or control. This chapter explores the economic and legal factors pertinent to the development of groundwater management (i.e. the establishment of control over groundwater extraction) by those who lived above these overdrafted groundwater basins.

I. B. Groundwater Management as Rent-Seeking Behavior

Extraction of groundwater to meet agricultural demands in the South Coast Basin began around the turn of the century. But by the 1940s, about the time the Metropolitan Water District first delivered water to its member cities, agricultural demands for water had given way to urban demands. Because urban demands for water quickened the rates of groundwater extraction from the basin, the resulting increase in groundwater pumping costs further hastened the transfer of land from agricultural to residential and industrial uses. When land is transferred from a lower valued use (i.e. agriculture) to a higher valued use (i.e. residential and industrial), the landowner accrues rents (or excess profits) as the payment for encouraging such a transfer. California's Correlative Rights Doctrine transfers a right to extract groundwater along with the transfer of ownership of the surface land. Purchasers of the land would profit from this water-with-land transfer as long as the use to which the water was put had a greater value than the cost of the water.

As more land was transferred to urban uses, and as more groundwater was extracted for these same purposes, groundwater overdraft worsened, groundwater costs increased, and the per unit profit from groundwater use began to fall. Threatened with the prospect of groundwater costs rising to profit-eliminating heights, water users on the South Coast Basin sought new sources of water. The Metropolitan Water District was formed to import water from the Colorado River to the South Coast Basin and to other places. However, when the Metropolitan Water District began delivery of water, it cost more per acre-foot than the the cost per acre-foot to extract groundwater. Few water users had incentive to use the more expensive imported water as long as access to groundwater was unrestricted. Access to groundwater meant the total cost of meeting water needs would be cheaper than if total needs were met exclusively by using the more expensive imported water, or if these total needs were met by a combination of local groundwater and imported surface water.

Urban demands for water raised the price people were willing to pay for water, and encouraged the development of the Metropolitan Water District to import Colorado River water to the South Coastal Plain. Water could be sold for a greater price per acre-foot to urban demanders than to agricultural demanders because the former apply the water to more highly valued uses and are willing to pay more for It. Use of groundwater, available at a lower cost per acre-foot than MWD water, to meet urban demands for water accrues rent to those who have access to it in lieu of MWD water. Ironically, the same growth in willingness to pay, that creates the opportunity to accrue rent, also threatens to destroy the rent because of the laws that allow all landowners to pump as much as they want from the groundwater basin. As the demand for water increases, so will the amount of water being pumped from out of a basin, and as more is pumped, the costs of groundwater pumping will increase. The average cost of groundwater pumping could be increased by such an amount that it would cost as much to extract groundwater from out of a basin as it does to purchase imported surface supplies. If the cost of groundwater equals the cost of alternative sources of water, then the previous rent-earning capability of the groundwater is destroyed.

As land and water use intensified in the South Coast Basin, more and more wells were allowed to be drilled into the basin according to the Correlative Rights Doctrine (i.e. the state's groundwater law). As more water was drawn from out of the basin, the costs of pumping the water increased, but until the cost of groundwater exceeded the cost of MWD water, no new entrant into the basin had an incentive to cease use of groundwater. However, the existing groundwater users, those with established wells which needed to be drilled deeper and deeper to keep up with the falling groundwater table, were suffering increased groundwater extraction costs. To prevent this cost escalation, those owning land overlying the basin needed to prevent others from opening new wells, drawing off more water, and thus increasing the cost of pumping. Feeling their property rights (to groundwater rents) were being harmed, the existing landowners appealed to the courts to stop additional pumping. In City of Pasadena v. City of Alhambra et.al. the courts responded by not only preventing new pumpers from entering the basin, but also by limiting the amounts the existing pumpers could extract from the basin.

The court's protection of the landowner's rights was achieved by eliminating the common property nature of the state's Correlative Rights Doctrine and substituting a private property rights structure wherein overlying landowners were given specific and separable rights to a quantified portion of the basin's safe yield. In most cases this private property right was protected against encroachment by others, was transferable to others, and could be used in perpetuity by its new owner. By quantifying groundwater production, the courts also limited

It. Extraction from groundwater basins was limited to the safe yield of the basin, so that those who needed additional water to satisfy their thirst for growth, needed to find alternative sources. This meant purchase of water from the Metropolitan Water District.

Without restrictions on groundwater extractions from a basin, the basin's growth and prosperity will threaten to erode the land's rent-earning abilities. Growth and prosperty may be due to the availability of inexpensive groundwater supplies, but extraction of groundwater in excess of the basin's safe yield (i.e. overdraft) will cause groundwater to become increasingly more expensive. Growth-induced increases in the rate of extraction, by increasing future pumping costs, will lower the value of the land. Thus if the land's value is to be maintained, then groundwater extractions need to be maintained at a level equal to the safe yield of the basin. Establishment of private property rights to groundwater is a means of restricting extractions from a basin, preventing overdraft of the basin, preventing increases in groundwater extraction costs, and maintaining the value of the land which overlies the basin.

Adjudication of groundwater rights is a means of establishing private property rights to groundwater. A groundwater adjudication is a legal proceeding in which all who claim rights to use water in a basin are parties to the proceedings. The decision of the court allocates the available supply among the competing claimants. Since the first groundwater adjudication, (City of Pasadena y. Citv of Alhambra. et al. which allocated the groundwaters of the Raymond Basin) the courts have relied upon a "physical solution" to allocate the available supply.[2] In a physical solution the competing claimants use the principle of adverse possession to establish a claim to extract groundwater equal to the maximum continuous amount extracted over a five

[2] A physical solution is differentiable from an economic solution in that the latter would allocate groundwater to US highest and best use. The resulting allocation would have the marginal value of groundwater equal across all groundwater users. Such a result is possible with the physical solution if exchange of groundwater rights is allowed.

year period. Adjudication resulting in a physical solution is the main form of groundwater management that has been instituted on the South Coast Basin.

Maintenance of "groundwater rents" involves the maintainance of the level of the water table. Groundwater rents can be increased by increasing the water table, because extractions costs are then decreased. In addition to establishing private property rights to the safe yield of the basin, a water table can be increased by contracting for "replenishment water" which is recharged underground to mix with the natural, local water in the basin. Replenishment water can be used to not only maintain the level of the water table, but as a means of providing additional water to supplement the local groundwater supplies. On the South Coast Basin, groundwater management includes not only the preventing of overdraft and the maintaining of groundwater rents,[3] but includes increasing the amount of water available to users of the basin by the purchase of replenishment water.

The initiation of groundwater management was the result of rent-seeking behavior by groundwater users. Groundwater became a valuable asset that if not protected would have been lost. To protect their groundwater supply, area water users followed a definite and consistent pattern in each and all of the basins. These steps were the (1) formation of a water users association to organize water users, (2) creation of a basin-wide water district, (3) annexation of the water district to the Metropolitan Water District to gain access to supplemental water, and (4) establishment of control over groundwater extraction. This

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[3] Groundwater management in the South Coastal Plain protects and distributes the rents earned from groundwater. Different management techniques evolved due to the unique physical, economic, and political attributes of each basin. Examples of these differences are (1) some basins are better able to undertake groundwater recharge programs (a physical difference), (2) a basin's water district may be dominated by either non-overlying landowners or overlying land owners (a political difference), and (3) groundwater use in the basin may be dominated by large or by small producers (an economic difference). As conditioned by the varying physical, economic, and political environment of the basin, different institutional arrangements for groundwater management were developed to protect and distribute the rents from groundwater use.

general pattern was the same for all basins, though the details of the groundwater management technique or plan varied because of the physical, economic, and political differences of the basins.

The following historical account of the development of groundwater management in the South Coastal Plain is presented to give insight into the similarities in the pattern of rent seeking behavior, and into how differences in the physical, economic, and political environment gave rise to differences in the observed groundwater management institutions. The following analysis neither takes the management of each basin in a chronological order, nor arranges them according to their institutional characteristics. Rather, groundwater management is viewed from the perspective of the river basin in which they developed. Of the five basins studied below, none is an isolated basin but each is interconnected and interdependent with at least one other basin. As the San Gabriel River descends from the San Gabriel Mountains to the Pacific Ocean, It flows through the Main San Gabriel Basin, the Central Basin, and the West Coast Basin. The growing shortage of groundwater, first in the downstream basins and eventually in the upstream basin, led to the movement of groundwater management "upstream" along the San Gabriel River, first in the West Coast Basin, then in the Central Basin and finally in the Main San Gabriel Basin. The Santa Ana River, flowing through Riverside and Orange Counties, bisects the Chino Basin and the Orange County Basin. Here too, groundwater management ran upstream starting first in the Orange County Basin before reaching the Chino Basin.

Groundwater management moved inland from the coast. It is inland where these rivers have their source, where most natural recharge of the groundwater basins occur, and where the increased costs from overdraft of the basins were last to occur. Since the basins along the San Gabriel River and along the Santa Ana River are interconnected, the groundwater basins along the coast suffered lowered water tables caused not only by their own pumping but also because the natural recharge water from "upstream" was being pumped out of the ground by the communities closer to the source of the water. Given the low cost of groundwater, compared to MWD water, the upstream pumpers were pumping rents away from the downstream groundwater users. The downstream users first organized to protect their rents, and as groundwater costs rose in the upstream basins, they too developed groundwater management institutions.

Delivery of Colorado River water to the South Coast Basin by the Metropolitan Water District created a price differential between less expensive groundwater and the more expensive imported surface water. It is this differential in water prices that created the rent-earning capacity of groundwater and encouraged landowners to manage this now more valuable resource. Recognizing this incentive and the role it played in creating it, the Metropolitan Water District developed water pricing policies to encourage groundwater management (i.e. rent protection). Also, the MWD encouraged water districts which applied for delivery of Colorado River water to completely encompass within their boundaries any local groundwater basin to facilitate conjunctive use of imported and local supplies of water.[4] Through its annexation policy and its water pricing policy, the Metropolitan Water District fostered the development of groundwater management on the South Coastal Plain, but ft was not until the local landowners appealed to the state's Supreme Court that the necessary institutions for management were made available.

One authority on the subject said that "The essence of groundwater management Is the skillful control of pumping from the underground 'common pool' reservoir to promote efficient and equitable long-term use of the water derived from it."[5] The means by which

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[4] Vincent Ostrom. Water and Politics. Los Angeles: Haynes Foundation, 1953, p. 187.

[5] Albert J. Lipson. Efficient Water Use in California: The Evolution of Groundwater Management in Southern California. Santa Monica: Rand Corporation, 1978, p. 3.

"the skillful control of pumping" was to be exercised on the South Coastal Plain was determined in City of Pasadena y. City of Alhambra et al,[6] In this case, "mutual prescription" was declared to bestow upon an individual landowner a private property right to groundwater. Mutual prescription grants to each pumper from an aquifer a prescriptive right to the amount of water he continuously pumped over the previous five years.[7] Management of the aquifer, by the control of pumping, was accomplished by (1) determining the "safe yield" of the aquifer, (2) determining the amount of each pumper's prescriptive right, called his "decreed right", and (3) decreasing every pumper's prescriptive right by the percent necessary to reduce actual total pumping to the safe yield. The adjudication of production rights required a time-consuming and expensive study of the basin's hydrology to ascertain its safe yield and to quantify every pumper's extractions over the previous five years. Mutual prescription became the starting point from which all groundwater management plans on the South Coastal Plain began.

II. Early Groundwater Management Efforts on the South Coastal Plain by the Metropolitan Water District

II. A. Development of the Metropolitan Water District

California's first artesian well was dug In 1868 near present day Compton by John G. Downey.[8] Like many would do after him, the ex-governor divided his 17,000-acre ranch into

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[6] City of Pasadena y. City of Alhambra et al.. 33 C. 2d 908,207 P. 2d 17, (1949).

[7] Because a prescriptive right is gained only to that quantity of water continuously pumped over a five year period, it is gained to the minimum amount of water pumped in any one of the fiv8 years. Anyone whose extractions from the basin were zero during any of the five years, gained no prescriptive rights to the basin's groundwater.

[8] Lynn Bowman. LosAnoeles: Epic of a City. Berkeley: Howell-North Books, 1974, p. 211. Downey was the state of California's seventh governor.

agricultural plots for sale to the Incoming farmers.[9] The sinking of artesian wells provided a year-round supply of water for irrigation, and the reaping of rents from the transfer of ranchland into agricultural land.

The drought at the turn of the century, according to William Kahrl, forced[10]

> many irrigators on the south coastal plain to sink wells which brought a rapid acceleration in the depletion of the groundwater basins that are the principal source for the area's rivers and streams. When precipitation returned to normal after 1900, these wells were not shut down; instead, they were continued in operation to serve an overextending range of agricultural activities in Corona, Ontario, Redlands, Riverside, San Diego, Los Angeles, and the San Fernando Valley. As a result, groundwater levels continued to decline after 1900, especially in the area of Los Angeles and Anaheim....

Agricultural growth and early urban development on the South Coastal Plain were made possible by the abundant groundwater reserves below the South Coastal Plain. But because the reserve of groundwater was limited, so was the growth that it could support.

In a study conducted at the request of the City of Los Angeles, the United States Geological Survey estimated in 1904 that twenty-five hundred flowing artesian wells on the coastal plain were draining the area's groundwater basins at a minimum rate of three hundred cubic feet per second, but that the overall artesian area of the plain had decreased to less than two-thirds of its original size.[11] Since the groundwater reserves of the South Coastal Plain were heavily developed, the City of Los Angeles, to provide water for its future growth, eschewed the groundwater resources encircling the city for the pure and plentiful waters found in the

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9 David Lavender. Los Angeles: Two Hundred. Tulsa: Continental Heritage Press, 1980, p. 47.

10 William Kahrl. Water and Power. Berkeley: University of California Press, 1982, p. 87.

11 United States Department of the Interior, United States Geological Survey, Water Supply and Irrigation Paper no. 139, Development of Underground Waters in the Western Coastal Plain Region of Southern California, by Walter C. Mendenhall (1905), pp. 16. Also see City of Los Angeles, Board of Public Service Commissioners, Complete Report on Construction of the Los Angeles Aqueduct. Los Angeles: Department of Public Service, 1916, pp. 39-43. Mendenhall also estimated that $2,413,000 had been invested in these pumping plants, or an average of Just under $ 1000 per well.

Owens Valley. Delivery of imported waters through the Los Angeles Aqueduct led to the almost immediate annexation to the City of Los Angeles of the San Fernando Valley and of many communities on the South Coastal Plain. Management of the groundwater resources of the San Fernando Valley, as the source of the Los Angeles River, has been developed in chapter two.

The South Coastal Plain did not have an imported supply of water available to it until twenty-eight years after the completion of the Los Angeles Aqueduct. The water source upon which the farms and communities of the area grew was found underground. Expanding demands for water In communities such as Santa Monica, Pasadena, Beverly Hills, and Long Beach, had to be supplied by increasing drafts upon the groundwater resources lying under them. First the region lost its artesian wells, then as more and more wells were driven into the ground, the water table from which the water was drawn sank deeper and deeper until in some areas during the 1920s, the pumps were pumping water from below sea level. Documenting the consequences of the South Coastal Plain's groundwater use, Vincent Ostrom notes that[12]

> An excessive draft upon the underground supplies existed in wells used for both agricultural and municipal purposes. On the site of the Centinela Springs which once flowed at the surface, the City of Inglewood drew water from a depth of 150 feet, or from below sea level. At the Copelin wells in Pasadena, the water level fell from a level of 154 feet when the first well was sunk in 1899 to a static water level of 190 feet in 1924, 223 in 1926 and 240 feet in 1929. The experience of both of these cities was typical of other municipalities in the south coast basin.

Because the groundwater reserves of the South Coastal Plain were insufficient to support the area's early growth in water demand, new sources of water were sought. During the 1920's the drought and the growth of the City of Los Angeles rendered the Los Angeles Aqueduct inadequate to meet the city's water needs, so in 1924 the city filed to appropriate water from the Colorado River. Led by the City of Los Angeles, eleven cities on the South Coastal Plain joined together to create the Metropolitan Water District to bring water from

[12] Ostrom,p. 169.

the Colorado River. The Metropolitan Water District, embracing the municipalities of Los Angeles, Anaheim, Beverly Hills, Burbank, Glendale, Pasadena, San Marino, Santa Ana, Santa Monica, Colton, and San Bernardino, was incorporated on December 6,1928. By 1931 the number of member cities had grown to thirteen with the addition of Fullerton, Long Beach, Torrance, and Compton, and with the deletion of Colton and San Bernardino.

San Bernardino withdrew from the MWD because its neighbor and rival city of Riverside voted not to join the MWD. Both cities draw their water from the Santa Ana River and from the Chino Basin. San Bernardino was reluctant to use the more expensive Colorado River water unless Riverside did likewise. Some of the water used by San Bernardino would percolate into the underground basin, providing to Riverside extra water at no cost. Such conflicts over the usage of common local supplies was a major stumbling block to annexation throughout the district's history.[13]

In 1931 a $200 million bond issue to build the MWD's water-import system was approved by the voters of the South Coast Basin, allowing construction of the Colorado River Aqueduct to begin in December of 1932. Colorado River water first reached Southern California in November 1939, and the first deliveries of MWD water for domestic consumption were made to Pasadena on June 17, 1941.[14] The first thirteen members of the MWD were municipalities.

Each member's share of Colorado River water is based on the ratio of the assessed property value within the member's territory to the assessed valuation of the entire membership of the MWD. In deciding upon district policy and procedures, members cast one

[13] Jerome Milliman, "History, Organization and Economic Problems of the Metropolitan Water District of Southern California," unpublished Ph.D. Dissertation, University of California, Los Angeles, June, 1956, p. 178.

[14] After traveling the 240 miles from the Colorado River to Lake Matthews, there remained 150 miles of distribution canals through which the water journeyed before it reached the original 13 member cities of the Metropolitan Water District.

vote for every ten million dollars of assessed property value, but no one member (i.e. the City of Los Angeles) is able to cast more than half the votes. The MWD discouraged the annexation of individual cities and encouraged the formation of local water districts to assure adequate assessed valuation within future members' territory.

To control the size of the water districts seeking to join the Metropolitan Water District and to encourage local groundwater management, the MWD in 1938 adopted the policy that the area of annexed water districts be "...of sufficient size and water requirements to justify as economically feasible the delivery of aqueduct water. Preferably such areas should be so located as to control the entire production of water from underground water basins affected."[15] The control of groundwater production would permit more efficient use of both surface and underground supplies of water and would "eliminate ruinous competition with irresponsible users who wanted to take a 'free ride' by increasing demands upon ground water supplies while their neighbors used more expensive Colorado River water."[16] Colorado River water, after being used by the people who paid for it, would seep into the nearest groundwater reservoir where It could be taken by anyone who operated a well. The heightened water table, buoyed by the return flows of MWD water, would lower the cost of pumping to all pumpers and make it economically rational for groundwater extractions to increase. However, by including within the district's boundaries the lands that overlie groundwater, the users who benefited from the return flow could be directly charged for the advantages they indirectly gained.

Because groundwater was still plentiful relative to population in the South Coastal Plain, and because groundwater was inexpensive compared to the cost of MWD water, water districts did not flock to the MWD as quickly as areas had become annexed to the City of Los Angeles when it provided imported water. To encourage membership, the MWD accepted

[15] Ostrom, p. 187.

[16] Ibid., p. 188.

applications from water districts that did not contain complete groundwater basins despite their 1938 policy mentioned above. If the policy of limiting member water districts to those which contained complete groundwater basins had been followed, the story of groundwater management in the West Coast Basin, Central Basin, Upper San Gabriel Basin, Orange County Basin, and the Chino Basin would not be as complicated and varied as it is.

II. B. Growth of the Metropolitan Water District

As late as 1943, Los Angeles County was the richest agricultural county and the most productive dairying county in the nation.[17] Because the southland was predominantly an agricultural region, the water demands by residential and industrial users, who were more willing to pay for the expensive imported water, had not yet led to a flood of annexations to the MWD. In addition, abundant rainfall during the early 1940s and the Mono Basin extension of the Los Angeles Aqueduct by the City of Los Angeles, delayed the growth of the Metropolitan Water District and the operation of the aqueduct at full capacity until after the post-war population explosion on the South Coastal Plain. But most importantly, local groundwater costs remained below those of the alternative -- water imported from the Colorado River by the MWD.

The first annexation to the Metropolitan Water District occurred in 1942 when a group of communities and irrigation districts extending from Newport Beach to Dana Point along the coastal portion of the Orange County Basin organized as the Coastal Municipal Water District. The cities of Brea and Newport Beach and the unincorporated areas of the Fairview Farms and Irvine's Subdivision Joined the Coastal Municipal Water District because rapid population growth and increased water demand along this narrow coastal strip caused the amount of

[17] Ibid., p. 4. The growth of the Los Angeles Metropolitan Area was not so much a fanning out of population from the coast to the east and south as it was an expansion of many isolated cities whose boundaries eventually crushed all signs of agricultural production between them.

groundwater extraction to exceed the basin's safe yield resulting In salt water intrusion into the basin that cut off fresh underground water supplies. Along coastal portions of groundwater basins, groundwater flows out of the basin and into the ocean. The pressure with which groundwater flows into the ocean provides a barrier against sea water contamination of that portion of the groundwater basin from which surface wells extract water. Extraction rates can be sufficiently high that sea water is able to enter the fresh water portions of a groundwater basin and contaminate the water which is extracted from the basin. If high salt concentrations can make groundwater unfit for agricultural or residential use, groundwater users must find surface water alternatives.

Further north along the coast in the West Coast Basin, rapid extractions of groundwater followed by salt water intrusion also forced the cities of El Segundo, Manhattan Beach, Hermosa Beach, Redondo Beach and Palos Yerdes Estates to form the West Basin Municipal Water District and join the MWD on July 23,1948. Lying on the basin's east side, the Gardena, Inglewood, and Hawthorne areas, which had not yet been directly affected by salt water intrusion, refused to join in the formation of the West Basin Municipal Water District. As a result of this refusal, the coastal cities initiated litigation to secure the adjudication of the water rights to the underground supply of the West Coast Basin and prevent nonmember areas from pumping local supplies while the cities nearer the coast line were forced to rely increasingly upon Colorado River water for their water supply.[18]

During the first five years of operation, the MWD was frustrated in its efforts to gain new members, but a dry spell from 1944 to 1951 encouraged enough areas to join the MWD so that its size was doubled.[19] The most important annexation was that of the San Diego County

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[18] Ibid.,p. 189.

[19] These "dry cycle" annexations made the Metropolitan Water District the state's largest water agency with over 1,000 square miles containing a population of over 4 million and an assessed valuation of nearly five and a half billion dollars.

Water District in 1947. Between 1950 and 1952, areas overlying the Chino Basin, the Orange County Basin, and the Central Basin also Joined the MWD.[20]

During the 1950's nearly 2 million people poured into the South Coastal Plain, making California the most populous state in the nation. Of the state's total population, nearly half of It was stuffed upon a plain which held only one-sixth of California's area.[21] Over 100 cities and unincorporated areas representing 7.5 million people had joined the Metropolitan Water District to have access to Colorado River water. The Metropolitan Water District grew from a water wholesaler to the regional water administration agency for the South Coast Basin. It should be added that all of the new annexations to the district were of the area-wide or basin-wide type rather than that of a single city. Perhaps because of the lawsuit by the city of Pasadena against competing groundwater users overlying the Raymond basin[22] the MWD was forced to recognize that In fairness to those who were both using expensive imported water and overlying a commonly used basin, its annexation policy should require that all pumpers overlying the basin be included in the district. If all pumpers were not part of the district, then those who did not join were enjoying benefits at the expense of district members. Hence

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[20] The following areas joined the Metropolitan Water District between 1950 and 1952: (1) Pomona Valley Municipal Water District in November of 1950 which included portions of the Chino Basin in Los Angeles County along with the cities of Pomona, Claremont, LaVerne, and Glendora; (2) Eastern Municipal Water District in July of 1951 which included the cities of San Jacinto, Hemet, Perris, and later the city of Riverside; (3) Chino Basin Municipal Water District in October of 1951 which included large sections of the Chino Basin in San Bernardino County along with Upland, Ontario Chino, and Fontana; (4) Orange County Metropolitan Water District in October of 1951 which included the northern and western portions of Orange County along with Huntington Beach, La Habra, Orange, Placenta, Seal Beach, and Tustin; (5) Foothill Municipal Water District in December of 1952; and (6) the Central Basin Metropolitan Water District in December of 1952 which included the cities of Vernon, Montebello, Whittier, Huntington Park, Bell, Maywood, Southgate, Lynwood, and Signal Hill.

[21] Lavender, p. 112.

[22] City of Pasadena v. City of Alhambra et al., 33 C. 2d 908, 207 P. 2d 17. (1949). It took twelve years, from 1937 to 1949, for this case to be adjudicated, however it was another six years, or until 1955, before all prescriptive rights were finally quantified.

to protect its members against "free riders" the district encouraged all areas seeking annexation to include territory conforming to underground basins or subbasins.[23]

In addition to the annexation policy of the MWD, efforts by the MWD to make basin-specific management possible included a program to encourage artificial replenishment. Each basin's management plan was to include provisions for the purchase of replenishment water from the Metropolitan Water District at a price less[24] than the cost of regular water. To encourage the use of replenishment water, the Metropolitan Water District charged two rates for water: a high rate for treated residential-quality water and a lower rate for untreated water. This two tier pricing policy was initially used by the MWD to encourage use of its water so that it could justify large appropriation claims from the Colorado River, but was subsequently used by the MWD to encourage groundwater replenishment activities. The lower price of replenishment water was designed to make it cost effective for districts to purchase the water, store It in groundwater basins, and use it at a later time.

Buying water for groundwater recharge requires an institution (i.e. a Replenishment Water District or local Munincipal Water District with taxing powers) for collecting the fees, through taxes, to pay for the water. Because the benefits of a higher groundwater table — the decrease in pumping costs -- are a public good from which no one individual can be excluded, without a public water agency with taxing powers some landowners overlying a

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23 Milliman, p. 290.

24 The MWD created two types of water: raw and softened. Softened water is raw water treated to meet residential quality standards. Raw water was to sell for one-half the cost of softened water. For example, from 1941 to 1948 the price ratio of raw water to softened water was $8/$15 (53%), from 1948-50 it was $8/$18 (44%), during the 1950s it was $10/$20 (50%), and in 1977 it was $36/$62 (58%). This preferential rate for artificial replacement or raw water was not due just to the cost of softening the water. The low price of raw water was and encouragement to replenishment of groundwater basins. Storing MWD water in groundwater basins was cheaper than building surface water reservoirs. By charging a low price for its raw water, the MWD was encouraging the use of groundwater basins as distribution, filtration, and storage systems.

basin would try to hitch a "free ride" by not paying for replenishment water while at the same time enjoying the benefits of a rising groundwater table. The annexation policy of the MWD was to assure that the boundaries of these districts would be drawn to encompass the entire basin, so that all those who benefit from the raised water table were the ones who paid the associated costs. Groundwater management to the MWD was a problem of distributing the cost of the replenishment water. Its policies of limiting annexation to districts overlying a basin, and of providing low-cost replenishment water, assisted the development of groundwater management in the South Coastal Plain.

Though each new area annexed to the MWD had been required to organize itself in relation to underground basins, the MWD was not "able to deal with the entire Southern California coastal plain as an integral hydrologic unit in providing for effective utilization and administration of water resources in the region as a whole."[25] The annexation policy was only marginally effective, because the interconnections between the West Coast, the Central, and the Upper San Gabriel basins along the San Gabriel River, and the Orange County Basin and the Chino Basin along the Santa Ana River made additional groundwater management necessary. These basins are only partially isolated -- the rivers that replenish each basin cause water demand in one basin to have an effect in another basin. Only if water demands had remained stable, would the MWD's policy have minimized conflicts over groundwater in the South Coastal Plain. But the region's continued growth in population and in water demand rendered the MWD's annexation policy ineffective in avoiding adjudication over groundwater rights.

The importance of the interconnectedness of the groundwater basins on the South Coastal Plain and its implication for management of these basins is explained by Albert Lipson in his Rand Corporation study of the evolution of groundwater management in southern California:[26]

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[25] Ostrom, p. 191.

[26] Lipson, p. 3.

> Groundwater management programs grew up in hydrologically interconnected basins along river systems. Those downstream and farthest from the sources of supply and hit first by shortages were the first to clamor for solutions. Gradually water problems moved upstream. Downstream users sought to protect their sources of supply from overuse by those upstream and took legal action to protect their water rights. The settlement of disputes between interconnected basins, mutually dependent on the same local surface supply sources, was a necessary part of the development of management plans within groundwater basins. Each area fought to protect Us share of the local water supply, to ration it among competing uses, and where necessary, to seek additional water.

III. Groundwater Management by Adjudication: The Raymond Basin and the Mutual Prescription Doctrine

It has already been mentioned that at the Copelin wells In Pasadena, the water level fell from 154 feet when the first well was sunk in 1899 to a level of 190 feet in 1924,223 feet in 1926 and 240 feet in 1929. The city of Pasadena, realizing its future water supply was in Jeopardy If it continued to rely entirely on groundwater, became a charter member of the Metropolitan Water District. The first deliveries of Colorado River water by the MWD for domestic consumption were made to Pasadena on June 17,1941. But before these deliveries were made, the city took legal action to curtail pumping in the Raymond Basin over which it stood. In 1937, the city of Pasadena initiated a suit against the downhill city of Alhambra to (1) determine water rights in the area, (2) curtail pumping, and (3) assure the expense of imported water would be paid by those who benefited from it. The major issue in the case became the manner in which water rights were to be determined and allocated among the parties who were pumping from a common groundwater reservoir.[27] The Correlative Rights Doctrine, as applied in earlier groundwater cases, would have made all producers overlying the basin equally responsible for maintaining the water table, and it would have eliminated claims by users who did not overlie the overdrafted basin. But rather than simply following

27 Ibid., p. 27.

the precedent of earlier groundwater cases, Pasadena vAlhambra was to become a watershed case In groundwater law.

In the first of the so-called "physical solutions" to groundwater management, the court determined the safe yield of the basin to be 21,840 acre-feet per year. Since pumping in the basin had exceeded 30,000 acre-feet per year, all pumpers from the basin were ordered to curtail their pumping by 27 percent in order that total pumping would not exceed the safe yield.[28] All pumpers, whether or not they used the water on land overlying the basin, were granted a prescriptive right to the groundwaters of the Raymond Basin and were ordered to cut back production by the prescribed percentage. No distinction was made between correlative rights and appropriation rights to the waters of the basin; rather all had been granted prescriptive rights to a fixed quantity of the basin's safe yield.

Before this case, the state's Supreme Court had held that overlying landowners had a correlative, or equal, right to the waters below their lands,[29] and that users of groundwater on land not overlying the aquifer were appropriators entitled only to that water in the aquifer that may be considered "surplus" water.[30] If there was no surplus, meaning a basin was overdrafted, these appropriators lost their right to extract groundwater from the basin and use it on non-overlying land. The existing law was not applied in this ruling because the judge felt that the "old rule" would have eliminated the rights and properties of certain (non-

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[28] The overdraft of 8160 acre-feet is 2755 of the actual pumping level of 30,000 acre-feet.

[29] Katzv.Walkenshaw,141 C. 116, 74 P. 766, (1903). Correlative rights to groundwater are like an implied contract among the users of the basin In that each has an equal right to use (have access to) the groundwater and each shares equally in the costs of depletion. The right to groundwater, as an appropriation right to surface water, was perfected by use. However, if any one user chose to delay his use of groundwater until the future, the court allowed him the option of having his rights quantified or predetermined by the court rather than by actual use.

[30] San Bernardino v. Riverside et al., 186 C. 7, 198 P. 784 (1921). Surplus water is water that flows into an aquifer but is not used by the overlying landowners. In other words, It is measured by the difference between the safe yield and the total extractions by the overlying landowners.

overlying) producers who had become dependent upon the waters of the Raymond Basin. Instead, he applied the theory of "mutual prescription" claiming that since all groundwater extractors — overlying and non-overlying users alike — had contributed to the overdraft, and had accepted the basin's deterioration (the basin had been in an overdraft condition since 1920), they all had lost their "old rule" rights. Overlying users had failed to protect, and thus had forfeited, their correlative rights. Rather, every pumper had gained a prescriptive right by adverse possession against the other users of the basin.[31]

Prescriptive rights gained by the producers are valuable assets or private property. Recognizing this, an "exchange pool" was arranged In the Raymond Basin allowing producers to lease or sell their pumping rights to others who had need of water beyond their decreed rights. This water-rights market, administered by the court-appointed watermaster, was a means of fulfilling the stipulation in article 14, section 3 of the California Constitution that water be applied to Its most beneficial and reasonable use. Those who value the water for less reasonable uses will be willing to sell their rights to those who value It for more productive uses; hence an exchange pool allows the water to flow to its most productive, reasonable, and valued use. Unlike the "old rule" that treats groundwater as the common property of all landowners overlying a basin, a prescriptive right Is a private property right that when paired with the ability to transfer it to another, encourages the use of groundwater In Its highest and best use. Furthermore, anyone who wanted to enter the basin as a new pumper was required to purchase a prescriptive right from someone currently producing In the basin.

Because of this decision's establishment of a prescriptive right as that quantity of water extracted within the previous five years, pumpers In other overdrafted basins had an

[31] Prescriptive rights are limited to the amount declared by the court and cannot ever be greater than this amount. Adverse possession is a means of gaining a prescriptive right by use of property belonging to another in such a manner as for the court to conclude that the original owner had forfeited his Interest in the property.

incentive to keep pumping and bear the short term cost of increased extraction costs because otherwise they would lose the chance to perfect a prescriptive claim to groundwater in the event the basins's groundwater rights became adjudicated. Any reduction in pumping would lessen the amount of future groundwater rights that they could gain by mutual prescription. The result of this decision on the South Coastal Plain was rapid rates of pumping, falling water tables, increased pumping lifts, salt water intrusion, and inefficient and uncoordinated utilization of groundwater and imported surface water supplies. In addition to its basin specific consequences, this ruling encouraged pumpers to keep pumping rather than take supplemental water from the MWD -- one of many reasons why only 246,000 acre-feet of Colorado River water were delivered by the MWD in the 1953-54 fiscal year, or 21 percent of its available quota of 1,212,000 acre-feet.[32]

IV. Groundwater Management in the San Gabriel River Basin

The West Coast Basin, the Central Basin, and the Main San Gabriel Basin are three Interconnected and interdependent groundwater basins that underlie and support the San Gabriel River. The Main San Gabriel Basin occupies the most advantageous position of the three by being the closest to the source of the water supply - the San Gabriel Mountains. From the mountains, the water flows southwest to the Whittier Narrows, and from there south through the Central Basin to the Pacific Ocean. Today the channel of the river is paralleled by Interstate 605 (i.e. the San Gabriel Freeway).

The growth of the war Industries during the 1940's put substantial strain on the water supplies of the San Gabriel River basin. Three-fourths of all water used in the South Coastal

[32] Lipson,p.29.

Plain was groundwater ,33 and increased demands for water soon resulted in overdraft of the basin. The estimated overdraft from the basins of the San Gabriel River system in 1944-45 was 10,000 acre-feet, or 22 percent of the total overdraft in all the basins of the South Coastal Plain.[34] This overdraft had increased to over 150,000 acre-feet ten years later, accounting for 37.5 percent of the total overdraft in the South Coastal Plain.[35] Overdraft was not only increasing at a rate of 10 percent per year along the San Gabriel River basin, but was increasing faster than in any other portion of southern California.

This increase in overdraft occurred during a decade when imported water was readily available. Use of imported water would increase return flows into the basins, raise the water table, make pumping less expensive (thus encouraging more pumping) and, hence, benefit all who pumped from the basin. But this benefit, though it reached many, would be paid for by only those few who bought the more expensive imported surface water. Reluctance to make use of this additional water was caused by the common property nature of the state's groundwater laws. institutional change was necessary to match those who paid for imported water with those who would benefit. Along the San Gabriel River system, this was accomplished by changing the property rights system in groundwater from that of common property to one of private property gained by mutual prescription, i.e. the physical solution technique pioneered in Pasadena v. Alhambra. Once private property was instituted, exchange of these rights was

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33 California Department of Public Works, Division of Water Resources, South Coastal Basin Investigation: Overdraft on Ground Water Basins. Bulletin No. 53, Sacramento: Department of Public Works, 1947, p. 43.

34 Ibid., p. 20.

35 The Metropolitan Water District of Southern California, 16th Annual Report, 1954. Los Angeles: Metropolitan Water District, 1954, p. 56. This report estimates that the region's 400,000 acre-feet of overdraft in 1954 consisted of 100,000 acre-feet in the Central Basin, 50,000 acre-feet in the West Basin, 20,000 acre-feet in the Chino Basin, 70,000 acre-feet in the Orange County Basin, 40,000 acre-feet in the San Jacinto Valley Basin, and 120,000 acre-feet In several small basins.

possible and taxes could be assessed against this property to pay for the purchase of water to replace the groundwater withdrawn from the basin.

IV. A. The West Coast Basin

The West Coast Basin extends over more than one hundred thousand acres, lying generally from Santa Monica east to the Orange County and Los Angeles County border, and south to Redondo Beach. In 1907 wells in the basin were drawing water from 35 feet above sea level, but by 1953 the water table had dropped to between 97 and 100 feet below sea level.[36] Pumping in the basin was estimated at 90,000 acre-feet per year, triple the safe yield of 30,000 acre-feet per year, resulting in an overdraft of 60,000 acre-feet per year. Because of this substantial overdraft, the groundwater in this "downstream" basin could exert little pressure against the ocean waters which stood on the western border of the basin. Salt water replaced fresh water in the inland reaches of the basin and in the wells that drew from the coastal portions of the basin. As early as 1932 the coastal portion of the basin was invaded by salt water -- proof that groundwater pumping was exceeding the basin's safe yield -- and by 1950 salt water had invaded along 18 of the 20 miles of the coast line and as far as two miles Inland.

By eliminating access to fresh groundwater, salt water contamination of wells was destroying a property right previously enjoyed by those who pumped fresh water from below

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36 California Legislature, Joint Committee on Water Problems, Underground Water Depletion Problems West Coastal Basin and Central Basin. Los Angeles County and South Coastal Basin. Orange County..., The Sixth Partial Report by the Joint Committee on Water Problems of the California Legislature, Sacramento: California Senate, June, 1953, p. 14, Statement by Ben Haggott, President of the West Basin Water Association. Hereafter, this reference will be called "Sixth Partial Report..."

their land.[37] To protect this property right, it became necessary to decrease the amount of pumping throughout the basin, and to do this required an adjudication of property rights to all of the basin's groundwater. To protect their access to fresh groundwater, water users in the coastal portions of the West Basin sued those further inland who were extracting groundwater from the basin. Beyond a decrease in pumping, the cessation of salt water encroachment also required the use of fresh water injection wells along the western border of the basin.

During the beginning of the Second World War large oil refineries and airplane factories were built as part of the war effort. These relatively new entrants into the basin used considerable quantities of groundwater. Older established heavy users such as the Dominquez Estate Co., the Montana Land Co., and the City of Long Beach suffered decreased groundwater supplies as a result of the increased heavy uses by the war industries. In an early attempt to rectify the problem, according to Ben Haggot, the president of the Palos Verdes Water Company, the "(l)arge producers in the West Basin ... attempted through mutual agreement to control and limit production and to adopt a program for recharge. However, the older water producers felt that their earlier and prior prescriptive rights had been established and were paramount, and that the later industrial producers should take secondary entitlement.... General agreement on restricting pumping apparently was highly improbable.... As a result of this Impasse, it was determined that the only effective method of reducing the pumping volume was through court adjudication."[38] The confidence of the older established pumpers that their

[37] Sea water has approximately 19,000 parts per million of chlorides. The fresh or "sweet" groundwater in the West Basin was approximately 85 parts per million of chlorides, whereas 250 parts per million is considered the upper limit of salt contamination for domestic consumption. Due to salt water contamination, wells in the basin produced water that ranged from 100 ppm to 15,000 ppm.

[38] Sixth Partial Report by the Joint Committee on Water Problems of the California Legislature, p. 14-15. During the war years there was no other source of water other than the groundwater to support all water needs. The MWD had not yet laid pipes to the West Coast Basin.

claims would be supported by adjudication was a direct result of the decision rendered in the Raymond Basin case.

In 1945 a suit was filed by the California Water Service Company, the City of Torrance, and the Palos Verdes Water Company against 151 defendants to determine the water rights of all producers in the basin.[39] A West Coast Basin Water Association, representing the area's water producers, was formed to find ways to reduce the overdraft and to seek a supplemental water supply. The association's first attempt to Join the Metropolitan Water District failed when the Inland cities of Hawthorne and Dominguez, enjoying groundwater from a portion of the West Coast Basin not yet contaminated by salt water, opposed paying taxes to the MWD for expensive Imported water they did not need. With boundaries drawn to exclude these uncooperative cities (though they did overlie the basin), the West Basin Municipal Water District was formed In 1947 and annexed to the MWD in 1949. Efforts of the West Basin Municipal Water District convinced the MWD to change its policy requiring new members to Include an entire groundwater basin.40

The Los Angeles County Flood Control District's experimental fresh water injection test near Manhattan Beach in 1950 successfully determined the feasibility of creating a fresh water barrier between the ocean water and the waters of the basin. The next year the Los Angeles County Flood Control District Act was amended allowing the district to establish conservation zones and to charge property taxes in these zones to pay for the purchase and injection of water for the fresh water barrier. Under the 1955 Water Replenishment

[39] California Wat8r Service Co. et al. v. City of Compton. Los Angeles County Superior Court, No. 506806,1945. In 1953, Ben Haggot, speaking more as president of the West Basin Water Association than as president of the Palos Verdes Water Company, said "this litigation is more or less in the nature of a friendly suit between parties anxious and agreeable to obtain a fair and reasonable settlement and solution of their difficulties."

[40] Lipson, p. 36. After salt water intrusion threatened their groundwater supplies, the cities of Hawthorne, Dominguez, Inglewood, and Gardena also joined the West Basin Municipal Water District.

District Act, the Central and West Basin Replenishment District was created In 1959 to assume financial responsibility for the fresh water Injection program. In addition to being able to levy property taxes to operate the Injection wells, the replenishment district was able to charge a user tax to those who, by continued groundwater extraction, created the annual groundwater deficits In the basin.

The major pumpers In the West Coast Basin voluntarily agreed in 1955 to reduce pumping by 26 percent and to an exchange agreement similar to that instituted in the Raymond Basin. Water levels rebounded nearly ten feet the first year after pumping was curtailed.[41] in August of 1961, sixteen years after the suit began, the court made its final decision which was to follow the mutual prescription doctrine established in the Raymond Basin by instituting a "physical solution" to the problem of overdraft. The court's management plan established a safe yield for the basin and then restricted pumping by each producer[42] so as to limit actual production of groundwater to the safe yield. When the suit began, all of the West Basin's water needs were met exclusively by groundwater, but by 1964 the basin was importing seventy percent of its water supply. Groundwater use was limited by the court's plan, so that water needs created by increased growth were met with MWD water.

IV. B. The Central Basin

The Central Basin covers 184,320 acres, or is about 83 percent larger than the West Coast Basin, and lies directly east of the West Coast Basin. Withdrawals in excess of safe yield had eliminated the former westerly flow of groundwater over the Inglewood-Newport Uplift which separates the Central Basin from the West Coast Basin. Overdraft In the Central Basin

[41] Edwin Cooper. Aqueduct Empire. Glendale: Arthur H. Clark. Co.. 1968. p. 120.

[42] The original suit had 150 parties. In 1949, 340 more parties were added, and in October of 1956 a second suit was filed to bring an additional 76 pumpers under the court's jurisdiction.

was estimated at 12,000 acre-feet per year In 1944-45, but had increased over six fold to 77,000 acre-feet per year by 1949-50, and to 100,000 by 1954. Though this area was covered by artesian wells at the turn of the century, wells were now pumping from 60 to 70 feet below sea level. Along the Central Basin's coastline, which stretches from San Pedro to Seal Beach, salt water had Intruded as far as two miles Inland. Salt water contamination of wells continued between Seal Beach and Newport Beach, but the most severe problems were found around the City of Long Beach.

The largest water user In the basin was the City of Long Beach, which had Joined the MWD In 1931. The Long Beach Water Department, using wells that were pumping from 50 to 60 feet below sea level, had been producing 30,000 acre-feet per year from Its well field that had a safe yield of 20,000 acre-feet per year. Though in 1947 the city used no Imported Colorado River water, it was unable to Increase its underground water supply because of the danger of Increasing the already existing salt water Intrusion.[43] By 1951 the city was purchasing 15,000 acre-feet of MWD water which represented 42 percent of the city's total supply. Assuming pumping costs of $7 per acre-foot and $ 10 per acre-foot for MWD water, the added expense from the need to import water rather than being able to pump it from the ground was approximately $45,000 per year. If salt water contaminated all wells, thus eliminating groundwater as a source of supply, the total water supply would cost the city $357,143 -- as opposed to $250,000 which is the cost if the same amount of water was pumped from the basin, or an additional $107,143 per year.

To prevent further Intrusion of salt water, the destruction of the groundwater basin, and erosion of the rent-earning capacity of the groundwater, the area's water users united to end overdraft and find a supplemental source of water. Imported water had been available for

[43] Statement by Donald Baker, consulting engineer to the Long Beach Water Department in "Sixth Partial Report...", p. 12.

these purposes for almost ten years, but fear of losing their pumping rights and of being the only ones paying for the more expensive MWD water forced Individual users to choose not to use it. Following the same procedure as the West Coast Basin -- annexation to the MWD followed by court adjudication of water rights -- the neighboring Central Basin organized Its own water association In 1950 to develop plans for groundwater management and surface water Importation. The Central Basin Municipal Water District was formed in 1952 and annexed Itself to the Metropolitan Water District to obtain a source of Imported water for the area. The Central Basin's water users association consisted of 60 members (mainly water companies, cities and Industrial users) who pumped 70 percent of all the groundwater in the basin. This small number of large competing users made it easier for the water users to negotiate a settlement among themselves without a costly adjudication procedure. The Central Basin and West Coast Basin water associations agreed to develop a water replenishment district[44] that extended over both basins. After the district was approved by the voters in November of 1959, a gross tax on all groundwater production was used to finance purchase of replenishment water from the MWD.

Also in 1959, the Central Basin Municipal Water District joined with Long Beach and Compton to file a suit against groundwater users in the "upstream" Main San Gabriel Basin.[45] The suit was aimed at determining mutually exclusive shares to the groundwaters beneath the two basins, which would increase the amount of water flowing into the Central Basin from the

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44 The 1955 Water Replenishment District Act permitted the counties of Southern California to organize a new type of district to raise funds to purchase replenishment water to supplement depleted basins, and to finance salt water intrusion barriers. The district's taxing power was to be applied to an entire area overlying a basin benefiting from the replenishment. "This was necessary because water districts created to bring in Colorado River water by annexation to the MWD had boundaries that did not conform to underground basins." See Lipson.p. 38.

45 Long Beach et al. v. San Gabriel Valley Water Co. et al., Los Angeles Superior Court, Case No. 722647,(1965).

Main San Gabriel Basin.[46] The conclusion of the West Basin's groundwater rights adjudication in 1961 provided a blueprint for the Central Basin to follow in adjudicating its groundwater rights. To curtail pumping within the Central Basin, the replenishment district initiated a groundwater rights determination suit in January of 1962,[47] at the request of the Central Basin Water Association.[48]

Accepting the curtailment of production that accompanies the use of mutual prescription, 47 producers responsible for 75 percent of the production from the basin agreed to curtail their extractions by 21 percent nine months after the suit was initiated.[49] The Main San Gabriel case, decided in September of 1965, helped in estimating the Central Basin's safe yield and contributed to the negotiations over curtailment of production by determining a fixed amount of water that would flow into the Central Basin. The court's decision concerning groundwater rights in the Central Basin was made in October of 1965, just three years after the suit began. The speed with which these decisions were made was an encouragement to others to rely upon court-sanctioned negotiated agreements, rather than upon adversarial adjudication.[50]

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[46] A 1947 report by the State Engineer set the safe yield of the basin at 175,000 acre-feet per year, but in 1951 the State Engineer reduced the safe yield of the basin to 150,000 because the rate of recharge had been reduced due to Increased pumping In the San Gabriel Basin above the Whittier Narrows.

[47] Central and West Basin Water Replenishment District v. Charles E. Adams et a).. Los Angeles County Superior Court No. 786656, (1962).

[48] Lipson.p. 41.

[49] Ibid. The final decision required a 20 percent reduction in extractions. The case, however, involved over 1000 parties.

[50] This encouragement is created by not only the speed with which extraction rights can be determined (i.e. court costs and other time-related costs are less), but the quantity of water pumpers are allowed to extract is potentially greater. Both the West Basin and the Central Basin had 100,000 acre-feet of overdraft, but though the West Basin groundwater users agreed among themselves to a 26% cut-back In water use (resulting In an amount of use way above the basin's safe yield), the court adjudicated rights equal to the safe yield. The Central Basin water users avoided adjudication and faced a cut-back of only 21 % in water use (a quantity way above the safe yield).

Similar to the West Coast Basin decision, mutual prescription was the basis for determining prescriptive rights of all parties to groundwater, all prescriptive rights were reduced by the same amounts so that the safe yield of the basin was not exceeded, and an exchange pool was established to provide water to those who needed it the most. New pumpers were not allowed to enter the basin unless they purchased pumping rights from those who were party to the adjudicated decision. Because the basin's physical characteristics allow quick absorption and transmission of replenishment water, the total available groundwater has come to exceed the safe yield of the basin, but because replenishment facilities are limited, pumpers are enjoined against pumping in excess of their adjudicated rights.

IV. C. The Main San Gabriel Basin

When the Long Beach case was filed in May 1959, the cities and water companies in the Upper San Gabriel Valley were virtually the only ones in the Los Angeles Metropolitan area which had not Joined the Metropolitan Water District. They had been able to hold out principally because of their favorable geographic and geologic location overlying the San Gabriel Valley's groundwater basin. The lawsuit was an effort to force the upper valley entitles to limit their use of water from the Main San Gabriel Basin and to share with the Central Basin the cost of importing Colorado River water.[51] Rather than challenge the lawsuit, the water users in the Main San Gabriel Basin negotiated with the Central Basin to determine the amount of groundwater that should flow between their two basins, which are separated by the Wittier Narrows.

Overdraft In the Main San Gabriel Basin began about 1960 due to the use of local groundwater to flush the area's sewage into the ocean during the 1950's. In 1966 an estimated 70,000 acre-feet of water was being exported out of the area, causing a decrease in

[51] Cooper, p. 127.

the return flows which otherwise would recharge the basin, and resulting In an annual overdraft of 40,000 acre-feet.[52] Following the pattern of their neighbors in the West Coast and Central basins, major water users formed a water association and sought the development of a management plan, to equitably distribute the costs of supplemental supplies to reduce overdraft and deliver water required under the Long Beach Judgment.[53]

The Long Beach suit was initiated in 1959, and concluded six years later in 1965. In response to It, the Upper San Gabriel Valley Metropolitan Water District was formed in 1959, and annexed to the MWD in 1963. The district planned to increase the amount of water in storage, meet the obligation of the Long Beach case, and prevent future overdraft by reliance upon replenishment water purchased from the MWD.[54] Unsoftened replenishment water was brought to the area, and the district charged a pump tax to raise revenues to purchase the water. But because two other water districts overlying the Main San Gabriel Basin[55] were not paying for the replenishment water, adjudication of groundwater rights in the basin was initiated in January of 1968.[56]

Again, the mutual prescription's physical solution -- the curtailment of all producers' production by a fixed percentage so that total production will not exceed the safe yield of the basin -- as used in the Raymond, West Coast, and Central basins, was adopted in the Main San Gabriel Basin, but with some major modifications. First, the watermaster is a nine member

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52 Lipson.p. 46.

53 Ibid. Under the terms of the Long Beach case, the Main San Gabriel's obligation to the Central Basin can be met by providing either a fixed quantity of water or the funds necessary to purchase that amount of water.

54 Ibid., p. 47.

55 The Pomona Valley Municipal Water District and the San Gabriel Municipal Water District. The latter of the two is made up of four widely scattered cities, Monterey Park, Alhambra, Sierra Madre, and Azusa, who get their water from the State Water Project.

56 Upper San Gabriel Valley Municipal Water District v. City of Alhambra et al., Los Angeles Superior Court, Case No. 942128, (1973).

committee, under the Jurisdiction of the courts, consisting of six local water producers elected by votes based on each water users' share of water rights, and three board members, one from each of the overlying municipal water districts. Second, the watermaster determines an "operating safe yield" which can vary year to year depending upon physical and economic considerations. And third, replenishment water Is purchased with revenue from a net pump tax which allows individual pumpers to exceed their share of the operating safe yield if they pay the pump tax on the excess water pumped. Water rights are also allowed to be leased or transferred throughout the basin.

The process of developing groundwater management in the San Gabriel River Basin followed the same course in each of the three interconnected groundwater basins. First a situation of overdraft and water shortage led to the formation of a local water users association with the intent of securing supplemental water. Groundwater rights were adjudicated and the vesting of private property rights allowed for imposition of taxes to equitably share the costs of purchasing imported water. Rights to groundwater were determined by the formula developed in the Raymond Basin -- safe yield determination followed by granting of prescriptive rights to individual producers. Pumpers may exceed their share of the operating safe yield, but when they do so they must pay an assessment to replace the excess production with replenishment water.

V. Santa Ana River Groundwater Management- Innovation to Avoid the Mutual Prescription Doctrine

Just as groundwater supported the growth and development of the areas along the San Gabriel River, the Santa Ana River area sprouted and matured by using the water that was held

In its underlying groundwater basins. Edwin Cooper describes the early history of the lower Santa Ana River Valley and the consequence of its reliance on groundwater as follows:[57]

> Most of the Santa Ana Valley, when the first pioneers found it, was "full to the brim," so that the surface of the ground was swampy in many places. Water for human use was ample as long as few people were there to use it. In fact, the county's boosters spoke with pride of its artesian wells, which sent geysers into the air. Farmers frequently had to drain low-lying ground before they could raise crops on it.
>
> As the years went by, the farmers worked hard and thrived. Population clusters expanded into cities. Artesian wells lost their pressure. Eventually great swaths of the valley were covered by mankind's handiwork. More and more agriculture, typified by the vast Irvine Ranch, more and more people, pumped greater and greater draughts of water. By 1926 the scales had tipped: water was being consumed, through wet years and dry, faster than it returned naturally to the ground. Soon marshy areas and artesian wells were only memories. The water table beneath the land began to sink out of reach of the pumps.

The challenge of a declining groundwater table was met by the landowners in the Santa Ana River system in a way different from those in the San Gabriel River system. The Orange County Basin groundwater users, dominated by the Irvine Company[58], asked the legislature to grant special district status to the area rather than appeal to the courts for adjudication of groundwater rights. The special district's taxing and purchasing powers, In combination with the basin's favorable physical characteristics for absorbing and distributing artificially recharged water, allowed a degree of control over the height of the groundwater table by the development of a massive replenishment program. Furthermore, upstream on the Santa Ana River, the groundwater users of the Chino Basin negotiated a most unique settlement to its conflicts over groundwater. Assisted by the decision in City of Los Angeles v. City of San Fernando[59], which drastically changed the requirements for mutual prescription, the groundwater users on the Chico Basin established three separate "pools" or groups of users of

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57 Cooper, p. 116

58 Edwin Cooper's Irvine Ranch entered the real estate development business as the Irvine Company.

59 City of Los Angeles v. City of San Fernando. 123 C. 3d 1 (1975).

groundwater, and allocated to these pools a share of the safe yield. Both solutions to the problem of falling groundwater tables will be presented below.

In the example of the basins along the San Gabriel River, it was shown that the downstream basin (the Central Basin) took action to adjudicate rights between themselves and the upstream basin (the San Gabriel Basin). Such Interbasin adjudication was necessary before Intrabasin adjudication could successfully proceed. (A similar senario is found in City of Pasadena v. City of Alhambra et al.). Actions leading to groundwater management along the Santa Ana River are very similar to those that occurred along the San Gabriel River. Post-war population growth resulted in severe overdraft problems and the dissipation of groundwater rents. To protect groundwater rents, the groundwater users sought means of restricting access to groundwater in the basins, and means of maintaining the groundwater table. However, there are some institutional differences in the means used to allocate groundwater within the basins along the Santa Ana River. These differences will be highlighted below, but they should not obscure the fact that they are examples of rent-seeking behavior by groundwater users.

V. A. The Orange County Basin

Overdraft in the Orange County Basin began in approximately 1930.[60] Angered by increased pumping cost caused by a lowering of the water table In the Orange County Basin, the area's water users, led by the Irvine Company, filed suit against water users overlying the Chino Basin upstream on the Santa Ana River to prevent them from usurping the water supply

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[60] See "Sixth Partial Report...," p. 18, statement by RossShafer, a "prominent water and land consultant of Orange County" says overdraft began in 1932. Edwin Cooper in Aqueduct Empire, p. 118, says overdraft began in 1926. And Albert Lipson said the salt water Intrusion problems began "during the 1920s", p. 68.

of the Orange County Basin.[61] In addition, by special act of the legislature in 1933, the Orange County Water District (OCWD) was formed to help spread the cost of this litigation among all those affected by the suit.[62] Property taxes were imposed to pay the costs of the suit, which was resolved in 1942 when upstream users agreed to restrain their use -- restraint that was supposed to lead to increased inflows into the Orange County Basin and an increase in the basin's water table.

To support post World War 11 growth in water needs, the area's water users sought additional supplies of water. The Orange County Flood Control District secured water from the MWD for replenishment of the Orange County Basin in 1948, and the next year the program was taken over by the Orange County Water District, which used property taxes to pay for the replenishment water. However, since the safe yield was 135,000 acre-feet per year and extractions from the Orange County Basin in 1950 totaled 190,000 acre-feet, there resulted an overdraft of 67,000 acre-feet. To increase the natural flow of water into the basin (as a means of eliminating the overdraft), the basin water users duplicated the strategy used in the previous decade. A law suit was initiated in 1951 against the cities of San Bernardino, Riverside, Colton, and Redlands which overlie the Chino Basin. This suit ended in 1957 with a verdict requiring each defendant city to provide its share of a quota of groundwater which was to flow over the Whittier Narrows into the groundwater basin beneath Orange County.[63]

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[61] Irvine Co. v. Fontana Union Water Co., Judgment No. Y-36-M, D.C. Cal., (1942).

[62] Upson, p. 65. Milliman calls the Orange County Water District a "basin protective association." As a county water district, its powers were different than those possessed by the Orange County Municipal Water District because of the difference In representation of these two types of districts.

[63] Between the Orange Coast Basin and the Chino Basin on the Santa Ana River is the Prado Dam. Though the Orange County Water District had successfully sued to assure its share of surface and groundwater flowing south from the dam, it was the spreading of replenishment water below the dam, water purchased from the MWD, that would supply the basin with the majority of Its groundwater.

Groundwater management In the Orange County Basin was Initiated not by a water users association made up of many local water users, but by the Irvine Company which owned one-third of all the county's land (I.e. a water users association of one). It was the Irvine Company which sued water users upstream on the Santa Ana River, established the Orange County Water District as its "publicly funded legal arm" to help finance water litigation during the 1930's,[64] and later encouraged modification of the district act to create the Basin Equity Fund of which it Is one of the largest beneficiaries. But following the same steps used In all the other basins which instituted groundwater management on the South Coast Basin, after interbasin rights were settled the Orange County Water District Joined the MWD in 1951,[65] As a means of managing the groundwater basin, the Orange County Water District Act was changed In 1953 to allow imposition of a pump tax to support the purchase of replenishment water, a property tax to purchase additional imported water, enlargement of the district to include the cities of Santa Ana, Anaheim, and Fullerton, and the metering of all groundwater production.[66]

The Orange County Water District, rather than initiate adjudication of groundwater rights to halt overdraft of the basin, based their groundwater management plan upon the use of a gross extractions tax or "replenishment assessment" to purchase replenishment water and to equalize the cost of groundwater and the cost of surface water. The replenishment assessment

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[64] Timothy H. Quinn "A More General Theory of Environmental Policy with an Application to the Evolution of Groundwater Law in California" Ph.D. dissertation, University of California, Los Angeles, Los Angeles, Calif, 1983, p. 364.

[65] The Orange County Water District included most of the land in Orange County except the cities of Anaheim, Fullerton, and Santa Ana which were original members of the Metropolitan Water District. When the Orange County Metropolitan Water District was formed to annex the area to the Metropolitan Water District of Southern California, it included the OCWD plus the three "island" cities and some fringe areas in the county.

[66] Soon after delivery of Colorado River water to Fullerton and Santa Ana, which began in 1941, over half of the water needs of these cities were met with imported water, and the increased return flow helped to temporarily alleviate overdraft in the area of the cities. These two cities, plus Anaheim, were charter members of the Metropolitan Water District.

was used by the OCWD to control not only the amount extraced from the basin but also the number of individuals who were extracting groundwater. Though this means of restricting access to and extraction from the basin were different from the means established by adjudication, the consequences were essentially the same. Furthermore, by charging taxes to purchase replenishment water, the OCWD essentially stretched its control over groundwater to include not only the groundwater stock but also the return flows or safe yield of the basin.

The replenishment assessment, authorized by the legislature in 1953, was designed to equalize the pumping cost of groundwater and the cost of using imported surface water. Pumping costs were estimated to be $6.50 per acre-foot, whereas water from the MWD was $ 10 per acre-foot, so the replenishment assessment was set at $3.50. To many small agricultural users, this 54 percent increase in groundwater costs had substantial income effects causing many to quit farming by selling their land to developers. However, compared to adjudicated basins where exit is compensated by the sale of agroundwater production right, these tax-Induced exits leave the small producer worse off. Nevertheless, the major effect of the replenishment assessment was that for new pumpers, the economic incentive to drill more wells in the basin was eliminated. The cost of water per acre-foot was the same rather water was extracted from the basin or purchased from the MWD, but the costs of drilling a well made the up-front costs of groundwater greater. The MWD was the more reasonable source of supply for all new entrants. The principal benefit of adjudication is its prevention of entry into the basin, however the replenishment assessment supplied this same benefit for the Orange County Basin groundwater users without the cost of adjudication.

The OCWD followed a "fill the basin" policy during the first decade of its use of the replenishment assessment.[67] Each year a pump tax revenue of $700,000 was added to a

[67] Between 1941 and 1953 the water table fell an average of 3.5 feet per year. After reaching its lowest level in the drought year of 1956, the water table rose an average of 5 feet per year between 1956 and 1964 (the last year of the policy).

property tax revenue of $250,000 to purchase 95,000 acre-feet of water - enough water to replace the 70,000 acre-feet per year of overdraft and replenish past overdraft with 25,000 acre-feet per year.[68] The legislature expanded the district's tax and water-purchase powers in 1961 by granting It authority to levy an additional pump tax for non-irrigation users, to buy additional water to store for future use, and to levy an added property tax on all water users. In 1964 the "fill the basin" policy was changed to a more flexible management plan to achieve maximum use of the basin over wet and dry cycles.

The district found that though its use of taxes and the purchase of replenishment water had stabilized the water table in the basin, the district had not gained sufficient control over individual groundwater extractions. The largest of groundwater users were causing "pumping holes" In certain areas of the basin because their rates of extraction were not controlled.[69] To gain this control, the district initiated a Basin Equity Assessment program designed to lower the rates of pumping and increase the use of surface water by the basin's largest water users. By increasing the cost of pumping and lowering the cost of surface water, the Basin Equity Assessment program encourages the large water users to substitute imported surface water for groundwater.

In operating the Basin Equity Assessment, the district establishes an estimated, maximum, basin-wide percent of total water use that should be fulfilled by groundwater - the

[68] Milliman.p. 362.

[69] In a pumping hole or pressure cone, usually caused by a very powerful pump, the water table is drawn down just in the vicinity of the one pump. The result is that surrounding groundwater rushes into this hole or cone, and the powerful pump is able to take an exorbitant amount of water from the surrounding area.

"basin production percentage." Any producer who exceeds this percentage[70] is charged the basin equity assessment on their excess production.[71] For example, If the basin production percentage is 70 percent, but a water user meets his needs by using 80 percent groundwater and 20 percent imported water, then he would be subject to the the basin equity assessment on the 10 percent of excess groundwater production. The revenues from this tax are put into the Basin Equity Fund and are used to subsidize the purchase of imported surface water supplies.

To encourage the largest of groundwater users to curtail pumping and to use more imported surface water, revenues in the Basin Equity Fund are used to subsidize the cost of surface water for "designated producers." A designated producer is a large water user, such as the Irvine Company, which uses large quantities of both imported surface water and groundwater. If a designated producer uses a smaller percent of groundwater than the basin production percentage (the total quantity of groundwater used does not necessarily decrease because a lower percentage of groundwater use can be obtained by using more imported surface water and the same or larger amount of groundwater), then revenues from the Basin Equity

[70] The basin production percentage establishes groundwater production as a percentage of total -ground and surface - water use. This percentage is different from that applied to prescriptive rights in the adjudicated basins. In the latter case, production rights for every producer are limited to a given percentage of their prescriptive rights and they are enjoined from producing in excess of this percentage. In the OCWD, production in excess of this percentage is allowed but then producers must pay the assessment to purchase imported water to replace the excess production.

[71] Water users who use only groundwater necessarily are charged the assessment tax since groundwater is 100% of their total water use. This feature of the basin equity assessment penalizes small groundwater users whereas mutual prescription is assumed to benefit the small producer by allowing him to produce his prescriptive right without any additional charges. However, the OCWD exempts those producing less than 25 acre-feet per year from any assessment.

Fund (BEF) can be used to pay part of the cost of the surface water purchased.[72] Those who exceed the basin production percentage are penalized by having to pay into the BEF whereas those who stay below the basin production percentage are rewarded with payments from the BEF.

The XWD has been successful in supplying replenishment water to meet the growing demands of the area without cutting back on either groundwater production or total water use. Replenishment water is spread in the forebay just below the Prado Dam and is quickly assimilated and transmitted to the groundwater users in the Orange County Basin which is southwest of the dam. The basin's reliance upon artificial replenishment was possible because of the ease and speed with which replenishment water is quickly absorbed and transferred throughout the basin. In essence, the groundwater basin is used as a natural distribution system. In addition, use of MWD water increases the return flows into the basin. The massive replenishment program has resulted in a level of groundwater use (350,000 acre-feet per year) far in excess of the natural safe yield of the basin (135,000 acre-feet per year), and allowed for the spectacular growth and development of Orange County during the 1970's and 1980's.

In summary, the water users in the Orange County Water District chose not to adjudicate individual groundwater rights nor to create an exchange pool. Instead, they appealed to the legislature for the creation of a district with special taxation and spending powers. Raising funds through both property taxes and pump taxes, the district is able to

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[72] One of the largest beneficiaries of the Basin Equity Fund has been the Irvine Ranch Water District which relies almost exclusively on surface water. Though it was not responsible for any pumping holes in the basin, the Irvine Ranch Water District became a designated producer whose use of imported water was subsidized by those who pay the basin equity assessment. The Orange County Water District was initially established as a "publicly funded legal arm of the Irvine Ranch to help finance water litigation in the 1930's." Its political position enabled it to benefit from the Basin Equity Fund, irrespective of its water use characteristics. See Quinn.

purchase replenishment water that supports the groundwater table and lowers pumping costs. Considering that there were over 3,500 wells in operation in the area in 1950, the process of creating a legislatively approved special district with taxing powers may have brought groundwater management to the basin sooner and at a lower cost than the process of adjudication. Though adjudication was not necessary, the pattern of leadership by local water users in gaining control over groundwater extractions and access to imported supplies as a solution to the problem of overdraft as observed In the basins along the San Gabriel River is the same general pattern followed in the Orange County Basin — just the type of control over pumping is different.

Y. B. The Chino Basin

The Chino Basin, lying upstream from the Orange County Water District on the Santa Ana River, underlies portions of Riverside, San Bernardino, and Los Angeles counties. The Chino Basin Municipal Water District was formed and annexed to the MWD in 1951 to meet the water needs of the growing area. When the Orange County Water District filed suit in 1963 to secure its portion of the waters in the Santa Ana River watershed, it chose to sue the cities of Riverside, Colton, Redlands, and San Bernardino rather than the water districts representing those cities, but nevertheless it was the Chino Basin Municipal Water District that defended the rights of the upstream users in the adjudication procedure.

After settlement of the case in 1969, which required the Chino Basin water users to provide a fixed average flow below Prado Dam for downstream use, the Chino Basin Water Users Association and the Chino Basin Municipal Water District began developing a groundwater management plan based upon artificial replenishment and mutual prescription. Legislation was passed authorizing a temporary nominal pump tax to finance the necessary hydrologic and historic use studies to support adjudication of groundwater rights.[73] In January of 1975, the Chino Basin Municipal Water District, with the approval of a producer's advisory committee, filed suit to adjudicate rights in the basin.[74]

Management of groundwater in the Chino Basin reflects the greater flexibility given to groundwater management adjudications by the San Fernando case.[75] Three separate pools of groundwater rights were created and the safe yield of the basin was allocated among them as follows: (1) a pool of agricultural users overlying the basin, which was given almost 60 percent of the safe yield of the basin; (2) a pool of non-agricultural users overlying the basin which was given 5 percent of the safe yield, and (3) the remaining 35 percent was given to a pool of appropriators, or groundwater users who did not overlie the basin. Individual groundwater rights, and the taxes to pay for replenishment water, vary across the three pools. Individual property rights to groundwater were not specified for the overlying agricultural users; members of this pool have correlative rights to their pool's share of the safe yield. Individual rights were specified for non-agricultural users overlying the basin, but these rights cannot be transferred separate from the land, meaning that though each acre of land has connected with It a specified number of acre-feet of water, if one wanted to buy or sell the water, the land must also be bought or sold. Individual prescriptive rights were specified for

[73] S.B. 222 sponsored by Senator Ayala in 1975 provided a three year pump tax and the formation of a producer's advisory committee to assist in the development of a management plan.

[74] Chino Basin Municipal Water District v. City of Chino. San Bernardino Superior Court, Case No. 16437.(1978).

[75] Los Angeles v. San Fernando et. al., (1975). The decision in this case made two modifications in the determination of groundwater rights by mutual prescription. The prescriptive rights gained under mutual prescription no longer were equal to the amount pumped over the previous five years of continuous use, but could be determined by other means that take into consideration the beneficial and reasonable use of the water. The second modification is that public entities such as cities cannot lose their rights by adverse possession. This strengthened the position of the cities who were the main appropriators from the Chino Basin.

the appropriators and these rights can be transferred. Furthermore, when the amount of water used by the overlying users declines below the pool's share, the appropriators can purchase rights to this "surplus water."

Revenues for the purchase of replenishment water are raised by replenishment taxes that are charged to producers in each pool if and only if that pool's aggregate groundwater use exceeds its share of the safe yield. When users in the overlying agricultural pool exceed their pool's share of the safe yield, replenishment water is purchased by taxing all users, big and small, a gross pump tax on all groundwater production. Whereas if non-agricultural overlying users exceed their pool's share of the safe yield, individuals are taxed according to their contribution to the excess extraction (I.e. a net pump tax). Replenishment water is purchased by the appropriators using a combination of a gross pump tax and a net pump tax.

The Chino Basin Municipal Water District was chosen by the area's water users as watermaster because it overlies 75 percent of the basin, had supported the area's interests in the earlier litigation, and had the necessary powers to purchase replenishment water. However, all major decisions of the district must be approved by a producer's advisory committee. The committee consists of producers from each pool; the relative size of each pool's representation on the committee being based upon the pool's replenishment water assessments. Because appropriators are expected to pay the lion's share of future replenishment assessments,[76] and since advisory committee voting is based on these assessments, appropriators appear assured of a dominant voice in basin policy-making.[77]

[76] Water use by the appropriators is expected to grow beyond its pool's safe yield, causing this pool to pay most of the replenishment water assessments. Agricultural water use is expected to decline and stabilize below the pool's safe yield allocation, which will create surplus water to be purchased by the appropriators.

[77] Lipson.p. 81.

The Ghino Basin's groundwater management plan has a mixture of the property rights structures found In the Raymond, West Coast, Central, and Main San Gabriel basins, and of the tax based controls used in the Orange County Water District. Of the three pools of users, only the appropriators are given quantified prescriptive rights to groundwater. "And within the pools, gross taxes and net taxes, or a combination of both, are used to purchase replenishment water. Nevertheless, the judgment in the Chino Basin case closely resembles the "old rule" of groundwater law which existed before Pasadena v.Alhambra. As was the design of the Correlative Rights Doctrine established in Katzv, Waikinshaw. the overlying landowners were given correlative rights to the groundwater, and any appropriators are able to expand their share of the safe yield only by purchase of excess or surplus water. This basin's groundwater adjudication modified the Correlative Rights Doctrine without resorting to the strict and inflexible allocations established by use of mutual prescription. Though this example of flexibility may assist future groundwater adjudications by providing for negotiations which can tailor groundwater rights to water demands, it may also hinder negotiations by increasing the willingness of some claimants to hold out on agreement for a greater share of the water rights.

VI. Analysis of Groundwater Management on the South Coastal Plain

VI. A. Introduction

The preceding sections of this chapter emphasized the similarity in the rent-seeking behavior of groundwater users in the managed groundwater basins of the South Coastal Plain. In short, that procedure is begun by a water users association that initiates adjudication which results in a limitation of groundwater pumping, the purchase of imported water to meet growing water needs, and the distribution of these costs among all water users by a public water district's taxing powers. Given that the groundwater users in a basin are able to protect groundwater rents by instituting groundwater management, the following section will emphasize the differences in the distribution of that rent across groundwater users. Differences in the characteristics of the groundwater users in a basin will be shown to result In different groundwater management institutions, which in turn result in different distributions of groundwater rents.

Rent accrues to groundwater users if they undertake management plans which keep the cost of groundwater below the cost of the next most expensive source of water. Groundwater costs are controlled by control over the height of the groundwater table. The groundwater table can drop to such a depth that the cost of groundwater extraction is equal to or greater than the purchase price of available surface water, and if this happens there are no rents to be gained from use of groundwater. Management of a groundwater basin is management of the rents that accrue to groundwater users. These rents are the incentive which motivate groundwater users to institute groundwater management. Rent-maintaining maintenance of a groundwater table is accomplished in one of two ways: (1) instituting a system of private property rights that quantify the rights of all individuals to the groundwater in a basin, or (2) charging of a tax to raise revenue to purchase replenishment water. These two types of controls are not mutually exclusive, and have been combined in a number of ingenious ways by the water users associations of the various basins.

in the adjudicated basins of southern California, Individual property rights have been established primarily by mutual prescription which grants to each pumper a prescriptive right to the amount of groundwater continuously pumped over a five year period. This prescriptive right is the maximum amount a producer may subsequently extract. Once the maximum amount of one's right is determined by mutual prescription, the actual amount one is allowed to extract, or the decreed right, is equal to a portion of the prescriptive right.[78] The sum of all decreed rights is equal to the safe yield of the basin, whereas the sum of all prescriptive rights is equal to the safe yield of the basin plus the amount by which the basin was overdrafted.

To those producers who are awarded prescriptive rights which fall short of their total water needs, their total water needs can be met by adding to their prescriptive groundwater rights a quantity of the more expensive but readily available imported surface water. The economic advantage of having a prescriptive right to an acre-foot of groundwater (i.e. the rent earned by the owners of such a right) is equal to the difference in cost between an acre-foot of surface water and an acre-foot of groundwater. Adjudication of prescriptive rights equal to the safe yield of the basin also means that the water table ceases to fall, and pumping costs stabilize. If the willingness to pay for water increases, whereas the pumping costs remain the same, the value of the prescriptive right increases. An important component of the adjudication process is that it prevents any new pumpers from entering the basin. The initiation of adjudication "stops the clock" on new additional groundwater extractions, halts the increase in groundwater extraction costs, and imparts value to the newly acquired prescriptive right. (Lipson, 1978: 20) Since both the rights of each pumper and the number of pumpers is limited by adjudication, the water level in the basin is maintained, pumping costs are stabilized, and the same future quantities of groundwater are assured to each pumper.

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[78] If, for example, over a continuous five year period total extraction from a basin is 150,000 acre-feet per year, and the safe yield of the basin is 100,000 acre-feet per year, then total overdraft is 50,000 acre-feet per year. One-third of total extractions are from overdraft, and two-thirds of total extractions equals the amount of safe-yield from the basin. Prescriptive rights will be granted to 150,000 acre-feet per year of groundwater, but the decreed rights will be two-thirds of the prescriptive right, so that the total decreed rights are 100,000 acre-feet per year. All pumpers, regardless of the size of their individual prescriptive right, would have a decreed right equal to two-thirds or 66.7 percent of the prescriptive right.

The Raymond Basin was the first to have private property rights established In the groundwaters of the basin, and its mutual prescription doctrine was applied in the West Coast, Central, Main San Gabriel, and Chino basins.[79] Implicitly, the mutual prescription doctrine creates two classifications of groundwater based upon the physical characteristics of the water. One class is the stock of water in the basin that supports the water table and a second is the flow of water into the basin. In the mutual prescription doctrine's "physical solution," decreed rights apply only to the safe yield of the basin which Is the flow component of the groundwater. The safe yield consists of all return flows from natural (precipitation and surface percolation) and artificial (percolation of waters imported into the basin) sources. The rights to the stock of water in the basin are retained by the watermaster created with the responsibility for carrying out the management plan. The responsibilities of the watermaster may lie with a public water district, the Department of Water Resources, or any other court-appointed individual.

Access to the stock of water in the basin is controlled by the watermaster (usually a local water district). In the Raymond Basin, access was forbidden-- an injunction was issued against pumping In excess of the basin's safe yield. However, in the other adjudicated basins access is granted, but use of the public management agency's "groundwater-stock property" by any individual is treated as if it damages a property right of the public agency. Because damages are incurred, the user must pay a fine for the damage, also called a use tax or an extraction tax. Revenues from this tax are then used by the public agency to purchase replacement water which repairs the damage to its groundwater-stock property.

[79] The Orange County Basin did not apply the mutual prescription doctrine, but relied on extraction taxes to control groundwater pumping. In the Chino Basin, the mutual prescription doctrine was applied indirectly, because instead of giving prescriptive rights to individual pumpers, pools of pumpers were allowed a share of the safe yield of the basin.

When total extraction exceeds the safe yield, the stock of groundwater is decreased, yet that portion of the stock may be replaced by purchasing replenishment water. Revenues to purchase the replenishment water may be raised by use of a gross extraction tax or a net extraction tax. If the net tax is used, a tax equal to the cost per acre foot of replenishment water is charged on all extractions in excess of the safe yield of the basin. The net tax on extractions in excess of the safe yield will raise enough revenue to replace the water overdrawn from the basin. If a gross tax is used, then the total cost of purchasing replenishment water to replace the overdraft must be divided among the total of all extractions from the basin, not just the extractions in excess of the safe yield. After determining the total amount extracted from the basin (safe yield plus overdraft) and the total cost of replacement water, this total cost is divided by the total extractions to achieve the dollar value of the gross tax which is then assessed against each acre foot of water extracted from the basin.

Establishment of private property rights by the courts to the safe yield of the basin creates a valuable asset for its owner. Creation of an exchange pool by the court creates a market wherein those willing to buy and sell production rights can reallocate and redistribute them after the court's Initial Judgment. Owners of production rights will value their rights differently according to the "value in use" as determined by the use to which the groundwater is applied. An exchange pool creates a "value in transfer" for the groundwater production right, or in other words, a market price is created by the exchange pool. If the value in use is greater than the value in transfer for an individual, then that individual would be a buyer of production rights, and if the value in use is less than the value in transfer for an individual, then this individual would be a seller of production rights. Because the seller receives more for the production right than it was worth to him, his wealth increases; similarly because the purchaser of the right receives something of greater value than the price he paid for it, his wealth also increases. A transfer of production rights is not necessary for wealth to accrue to an owner of the right, because if an alternative source of water were more expensive than the water made available by the production right, the implied value of that right (i.e.the wealth It grants to its owner) is the difference between the total cost of the two alternative sources of water.

Adjudication of groundwater rights imputes an economic advantage to a landowner overlying an aquifer. Before adjudication of groundwater rights, this value is subject to diminution by others, and can be captured only by selling the land overlying the basin. But after adjudication, groundwater rights are severed from the land and given value of their own. Adjudication increases the wealth of groundwater pumpers first by creating a new asset (the prescriptive right) and second by protecting that asset's value from encroachment by others (as would have occurred under the previously existing common property rights). The wealth created by the courts is distributed among producers in the basin according to their historic production. After adjudication, producers redistribute this wealth among themselves by buying and selling their production rights. Adjudication's reallocation of wealth among the basin's producers can be predicted beforehand and, furthermore, may have an effect upon the type of public management agency established by the producers in the basin.

VI. B. Rent Redistribution in Managed Groundwater Basins

The following draws heavily from Timothy Quinn's "A More General Theory of Environmental Policy with an Application to the Evolution of Groundwater Law in California." His dissertation attempted to predict the direction and magnitude of post-management wealth transfers which would exist in a basin as a function of the basin's growth, the type of groundwater management techniques used, and certain characteristics of producers, such as their number and size. However, Quinn underestimates both the volume and direction of wealth transfers in adjudicated basins by assuming that only beneficial wealth transfers accrue to those who sell their production rights. Transfers of production rights take place because both the buyer and the seller benefit from the transaction. The one who sells his production rights receives cash in the exchange, but the purchaser receives a right to a flow of future rents made possible by his use of groundwater. Nonetheless, this section of the chapter presents Quinn's findings to assess the economic incentives that encourage management of groundwater -- incentives suggested by the post-management rent redistributions found in the managed basins of the South Coastal Plain.

VI. B. 1. The Incentive to Initiate Groundwater Management

When a groundwater rights adjudication Is Initiated, the distribution of production rights In a basin can be characterized by the moments of a frequency distribution. A frequency distribution is a relationship between the quantity (i.e. number of acre-feet) of the production right held by each producer and the number of producers who hold those sized production rights (See Figure 3-2). The first moment of the distribution, called its mean, indicates the central tendency of the distribution and measures the average size of the production rights. The second moment of the distribution, or variance, will show the dispersion of the production rights about the mean. And the third moment, or skewness, indicates the symmetry of the distribution. The measure of skewness will determine whether the production rights are concentrated in the hands of small groundwater users (i.e. a positive skew) or in the hands of large groundwater users.

The latter two moments of the frequency distribution of the pre-adjudication production rights characterize the type of wealth redistribution expected after the adjudication of rights and after the voluntary transfer of production rights in an exchange pool. A widely dispersed distribution will be associated with an "active market" having substantial potential wealth transfers, because it is assumed the small producers will sell their rights to the larger producers.[80] The skewness of the distribution will indicate the direction of the wealth transfer between the different sized groundwater producers. If the distribution is positively skewed, there will be many small sellers and fewer large buyers, and in the absence of collusion by the buyers, most of the wealth will flow to the small and numerous buyers.

Table 3-1 summarizes some available information on the distribution of production rights in each of the adjudicated basins. For each of the adjudicated basins, the table shows the year the number of groundwater rights was determined (Judgment), the number of producers granted production rights (#Producers), the acre-feet of groundwater determined as the safe yield of the basin and granted to producers as decreed rights (# Rights AF), the average amount of groundwater per production right (i.e. the size in acre-feet of the average producer) at the time of the judgment (Mean AF), the median amount of production (Median AF), the standard deviation of production as a measure of dispersion (Std. Dev.), and the skewness which indicates the size of the majority of the producers (Skewness).

The most noticeable characteristic of the basins is their statistical variety: The Central Basin has over 20 times as many producers as the Raymond Basin, and the production rights in the Main San Gabriel Basin are nearly 8 times as large as in the Chino Basin. The one statistic consistent across all basins is the positive skewness. This statistic tells us that in each basin there were many smaller than average producers, yet few very large producers who were granted decreed rights. This is a result of two growth patterns that transpired in

[80] Most adjudications happen in the early stages of urban growth, resulting in production rights being distributed to many small, often agricultural, producers and to a few, but large, urban producers. The smaller producers in the South Coast Basin were generally agricultural users of groundwater. Once they had water rights separable from the land, they generally sold those water rights to urban interests. The larger urban users of water were fewer in number, but owned large quantities of groundwater rights. This transfer of groundwater from small to large users may not have taken place if all water users were in the same business - i.e. all agricultural users or all urban users. More than differences in size it is differences in willingness to pay that explains why a widely dispersed set of production rights would lead to an active market.

these basins. The timing of growth before adjudication left a large group of small users who used groundwater for agricultural purposes in one tall of the distribution, and in the opposite tail of the distribution were a few large water users responsible for meeting the water demands of the urban population. Secondly, the few large water users were the most recent of groundwater users in the basin and it was their large demands upon the basin that led to the incentive for adjudication.

The large skewness of the Central and Chino basins compared to the Raymond, West Coast, and Main San Gabriel basins means that the producers In the latter three basins were of relatively equal size compared to the former two basins, but nonetheless large producers were a minority of the total number of producers and were demanders of groundwater rights offered for sale. The presence of a few, large, urban pumpers in the midst of many small agricultural pumpers, as shown by the positive skewness, creates two incentive which led to the adjudication of the basins based upon prescriptive rights. First, prescriptive rights allowed the large groundwater user to reduce the quantity of more expensive surface water they would need to purchase. (Prescriptive rights also allow the established water users, large or small, to protect their groundwater rents against encroachment dur to urban growth). Secondly, the small, well-established, agricultural groundwater users who no longer found farming profitable, had the option of selling their groundwater rights to the much larger, often more recently established, urban groundwater user.

Also from the skewness, and somewhat from the number of producers, we can see an explanation of why some basin water users acted differently than their neighbors when deciding upon the technique for groundwater management. In the basins with large numbers of groundwater users -- a large number of groundwater users who were threatened with dissipation of rents if groundwater management was not instituted -- the management process began with the formation of a water user's association to spearhead not only the adjudication of rights but the Joining of the MWD to procure additional supplies to meet the needs of those who would not gain groundwater production rights. On the other hand, no user's association was formed in the Raymond nor Orange County basins, the two basins with the smallest number of producers. The large size of a dominant groundwater user - the City of Pasadena and the Irvine Company respectively - led to a more direct form of action or rent-seeking on their part without the additional costs of forming a user's association. It would appear that the benefits from management outweighed the costs for these individual groundwater users, and that the marginal benefits of expanding their numbers was exceeded by the costs of doing so. These large users had a big enough stake in the benefits of groundwater management that it paid them to incur the costs necessary to bring this about. No single small user would have such an incentive; rather, many small users must Join together to spread the costs of initiating management across a sufficient number before the benefits of management outweigh the costs.

Dispersed, positively skewed distributions of groundwater producers suggests the presence of economic incentives that will lead to the adoption of groundwater management by adjudication. Two forces, one from each tall of the distribution, assist the creation of a groundwater management plan in a positively skewed basin. When basins are made up of identical producers, leadership in rent-seeking may not be readily forthcoming unless there are unusual circumstances, but a large water user's conspicuous position may make it a logical choice as a leader. if, as was the case in Southern California's adjudicated basins, the largest producers are cities or water districts servicing a fast growing urban area, then adjudication of rights and the creation of an exchange pool benefits the large users. Because the higher valued urban needs are met by the large groundwater producers, they will purchase groundwater production rights in the exchange pool, which not only allows them to forego the purchase of more imported surface water but minimize the cost of surface water transmission and distribution facilities.

A positively skewed distribution also means there are many small producers in the basin. With the prospect of having production rights to sell at a price greater than the value gained from using the groundwater, the small users will have an incentive to accept adjudication of rights in the basin. This generally has been the case in the adjudicated basins where the small water users were also agricultural users to whom the use of the groundwater, on average, is less valuable than to the large users such that the exchange value of their rights (i.e. the market price) exceeded their value in use. Though the small water users were the largest group and stood to gain the most wealth in the transfer of production rights, it was the large producers who assumed leadership in the development of groundwater management plans.

In comparing the adjudications in the Raymond and Main San Gabriel basins, both were initiated by the largest of water users who were attempting to force others overlying the basin to share the costs of importing MWD water. In both these basins the number of users was small (26 and 130 respectively), each producer was a large producer (average production is 1177.8 and 1615.4 acre-feet respectively), and producers were similar in their productive behavior (skewness was 2.84 and 3.41 respectively). But a more important similarity Is found in the relation of these large water users to the other users of the basin. In the Raymond Basin, the city of Pasadena, on the upstream section of the basin, and one of the first cities to join the MWD, had a disadvantaged physical position compared to the other water users overlying the basin. The Upper San Gabriel Valley MWD had been burdened with the full responsibility of supplying the requirements of the Long Beach case though it was not the sole user of the groundwaters of the basin, so it had a political disadvantage compared to the other users of the basin. These physical and political differences created an incentive for initiation of an adjudication of groundwater rights in each basin. Leadership was clearly established by each basin's main water user -- the city of Pasadena and the Upper San Gabriel Valley Municipal Water District -- and it was through their efforts that adjudication was begun.

Disadvantage, in terms of physical location in a basin or in terms of one's responsibility in allowing groundwater to pass on to others, adds incentive to explaining human behavior (i.e. Initiating groundwater management) beyond the explanatory power of the numbers in Table 3-1. Orange County Basin's downstream location from the Chino Basin was a disadvantage that its groundwater users were able to minimize by suing the water users in the Chino Basin to assure a fixed quantity of groundwater would flow below the Prado Dam. The Central Basin used the same strategy against the Main San Gabriel Basin water users. And it was the cessation of groundwater flow over the Whittier Narrows from the Central Basin to the West Coast Basin which necessitated the latter basin's water users undertake adjudication of groundwater rights in their competition to attract future growth, these areas of the South Coast Basin paid close attention to the differences in water prices between their communities. High water costs would drive industries and families to other areas, and without Industries and families moving into an area, neither growth nor a large tax base were possible. Community leaders thus respond to rent differences that arise from differences in water prices. To community leaders, rent, a surplus of benefits over costs, can be increased if their water costs are less than in competing communities, and to them this rent acts as an incentive to initiate groundwater management.

Leadership in the West Coast, Central, and Chino Basins was established not by a public body but by a group of local water users. In the West Coast Basin, 19 members of the water users association, making up 42 percent of groundwater production, voluntarily agreed to reduce their pumping by 26 percent nearly six years before the court announced its decision; and 47 members of the Central Basin's water users association, responsible for 75 percent of the basin's extractions, voluntarily agreed to reduce pumping by 21 percent only nine months after their suit was filed. This leadership by voluntary reductions was not for the purpose of gaining converts to their cause, but to convince the courts of their willingness to accept a physical solution to groundwater management. Likewise, the physical solution was adopted in the Chino Basin because the appropriators were willing to bear the largest part of the costs of the solution (paying replenishment assessments) in return for a "predominant voice" In future management decisions (since watermaster voting is based upon replenishment assessments paid) and for a guarantee of having groundwater available in the future to meet their growing water needs.

VI. B. 2. The Consequences of Groundwater Management

Beyond the static picture drawn from the above statistics, dynamic characteristics of the basin and of its producers are very important in determining the types of wealth transfers that encourage and follow adjudication. The incentive to support basin wide adjudication comes from the beneficial wealth transfers that accrue to those who are able to exchange production rights. Table 3-2 summarizes the transactions (both purchases of production rights and leasing of those rights) in the adjudicated basins by showing the number of original producers granted production rights (# Producers), the number of producers involved in transactions (leases or sales) of their production rights between the time of the final judgment and 1974-75 (Transactions), the percentage of these producers who have either sold or leased water rights during that time (%Active), the percent of the total production rights (i.e. safe yield of the basin) that has been involved in the transactions (% AF), and the last two rows show the net transactions (a negative number denoting sales and a positive number denoting purchases) by those producers who are smaller than the basin average and by those producers who are larger than average.

What can be seen from Table 3-2 is that though the majority of water users in every basin have been involved in an exchange of water rights (% Active is very high), these transactions have involved a small fraction (% AF is no more than 24 percent) of the total production rights in the basin. Many transactions of a small amount suggest that the basin's small producers were selling their rights to the large producers. When the transactions are broken down into those undertaken by the smaller than average producer and those undertaken by the larger than average producer, we see that in every basin, the smaller than average producers sold more production rights than they bought (net transactions are negative), and the larger than average producer bought more rights than they sold (net transactions are positive).

Table 3-3 shows in greater detail the small sellers and the large buyers in the market for production rights. Data for this table concerns only the buying and selling of production rights from the time of the basin's adjudication of rights to the year 1974-75 (i.e. leasing behavior is not included). This table includes the number of producers (# Producers), the number of these producers who were net sellers of production rights (# Sellers), the amount of production rights or acre-feet per year of groundwater that was sold (AF Sold), the amount of groundwater that was sold by producers ceasing production and exiting the basin (AF Exit/Sale), the percent of total groundwater sales that consists of sales due to producers exiting the basin (% Exit/Sale), the number of buyers in each basin (# Buyers), and the percent of the total groundwater sales that went to the four largest buyers in the basin (% 4 largest).

Producers exiting the basin supplied no less than 80 percent of the production rights sold in the exchange pool. Small producers exiting the basin -- usually those who were earliest in the basin with small shallow wells not worth the added investment necessary to reach the lowered water table -- were by far the most important source of supply to the demanders of water rights. On the other hand, the buyer side of the market is very concentrated. In three of the four basins, over 75 percent of the purchases of groundwater production rights was by the four largest producers in the basin. Generally, these buyers were the leaders in the movement to adjudicate the basin's groundwater rights, and, as shown from their market behavior, value the groundwater rights higher than those who exited the basin.[81]

Dynamic forces such as an area's growth have been shown to motivate the rent-seeking behavior of a basin's groundwater users. Market forces also affect the ability of those users to redistribute rents among themselves. Just as growth leads to the opportunity to capture groundwater rents, differences in the size of water users result in different values being placed on groundwater by those users. These different values lead producers to call for adjudication of rights which creates the ability to transfer groundwater rights to the highest and best use. By such transfers, both the small sellers of rights and the large buyers of these rights benefit by an increase in their wealth.

VI. B. 3. The Basin Equity Assessment - Rent Transfers Without Adjudication

Different management practices result in differences In the distribution of groundwater rents. The management plan established in the Orange County Basin during the late 1960's, during which the basin experienced its most rapid growth rates, was able to capture groundwater rents (by preventing access to the basin and controlling the level of the water table) without going through the adjudication process. But because property rights were not

[81] Often the San Joaquin Valley groundwater users are criticized for not following the lead of southern California's groundwater users by adjudicating groundwater rights, and their response is that adjudication was possible because the MWD provided a supplemental source of surface water to replace the difference between pre and post adjudication use. However, the analysis above shows that another main difference, difference in willingness to pay, led to an increase in the amount of water available to groundwater users.

established in the safe yield of the basin, the distribution of those rents (i.e. the types of wealth transfers) was very different than in the adjudicated basins. Rather than establish private property rights, the Orange County Basin's groundwater management technique used a replenishment tax to control access to the basin and maintenance of the groundwater table was achieved through artificial recharge financed by a replenishment tax.

By the time groundwater rights adjudication suits were filed in the Raymond, West Coast, Central, and Main San Gabriel basins, these basins had experienced the transition from agricultural demand to urban demand for water. In addition, there had been steady rates of growth among the largest of water users In the basin, and this growth gave them incentive to adjudicate water rights. Adjudication furthermore benefited the small agricultural groundwater user because their rights were quantified and made exchangeable -- i.e. the courts created an asset where none had existed before. But in the Orange County Basin, groundwater management was initiated by the county's largest agricultural groundwater user. Management of the basin began without the incentive to establish a market in production rights because there was not a group of large users supplying water to an urban population and willing to pay a price high enough to transfer water from agricultural to urban use. Being the largest landowner in the county, the Irvine Company also stood to gain an increase in wealth by developing its properties for residential rather than agricultural uses, so no transfer of water from a small to a large groundwater user was necessary.

The "post groundwater management" annual growth rate in total water use in the Raymond, West Coast, Central, and Main San Gabriel basins was. 6 percent,. 4 percent,. 3 percent, and .2 percent respectively. These are relatively low rates of growth showing that groundwater management was instituted after growth in these basins had peaked. Such was not the case for the Orange County Basin. In the five years after the Basin Equity Assessment was instituted in 1969 in the Orange County Water District, total water use grew at a rate of 3.1

percent, and from 1974-75 to 1980-1981 the growth rate was 3.6 percent. The first form of groundwater management during the 1950's -- the replenishment tax and the "fill the basin" policy — was Initiated before the first peak of the county's growth in the early 1960's, and likewise the Basin Equity Fund was created a few years preceeding the second growth peak in the middle 1970's. Leadership to protect pre-growth groundwater rights was not lacking, nor did the process of rent-seeking substantially differ from other basins.

Fifteen years after the replenishment assessment, the powers of the XWD were expanded by the initiation of the Basin Equity Assessment (BEA) plan which affected approximately 95 pumpers in the basin. This management plan requires the establishment of the basin production percentage, application of the Basin Equity Assessment against those who fail to stay below the basin production percentage, and use of the Basin Equity Fund to subsidize the price of imported water.[82] The effect of this program is to allow the largest water users (those who have access to imported water) to benefit from groundwater management at the expense of the smaller producers.[83] Most smaller than average groundwater producers (the average producer extracts 242 acre-feet per year) must pay the

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[82] The Basin Equity Assessment begins by establishing the percent of total water use which "should be" met with groundwater and that percent to be fill by surface water. Those water users who use a higher percent of groundwater than the above "goal" are using more groundwater than they "should be". These water users are assessed a penalty, the payment of which goes into the Basin Equity Fund. Those water users who use less groundwater as a percentage of their total water use than they "should be" are rewarded by being paid out of the Fund a subsidy to purchase surface water. The Basin Equity Assessment acts like a subsidy on groundwater use since those use are paid from the Fund may actually use a greater quantity of groundwater than those who pay into it -- it is just that their total use is large compared to their groundwater use, so that the percentage of groundwater use is small. Nevertheless, the Basin Equity Assessment subsidizes the large water users at the expense of the small water users.

[83] Groundwater use accounts for about 60 percent of total water use in the basin, but the basin production percentage is set at 70 percent, and the large producers on average use 38.4 percent groundwater in their total water use. If the basin production percentage were lowered (i.e. to 60 percent), then more smaller producers would have to pay the assessment tax, and more money would be available for the large producers through the Basin Equity Fund.

basin equity assessment because groundwater use is a large percentage of their total use. In 1974.-75, there were 79 small water users making basin equity assessment payments on 5,000 acre-feet of production, and contributing nearly $ 140,000 into the Basin Equity Fund. That same year the five largest water users in the county received $ 188,370 from the Basin Equity Fund to purchase additional supplies of imported water. These figures suggest that the basin equity assessment is a tax that increases the groundwater production costs and lowers the wealth of the small producers. On the other side of the ledger, the money from these assessments are put into the Basin Equity Fund where they enhance the wealth of the largest producers.[84]

Explaining the wealth distribution effects of the Orange County Basin's management system, Timothy Quinn states that:[85]

> [L]1ke all other groundwater producers in the basin, these very small producers must pay the replenishment fee on all groundwater production... As a result, many of these producers have exited the basin. Allocatively, this result is very similar to outcomes in the adjudicated basins. Distributionally, there is a very fundamental difference: In adjudicated basins, small producers are, in effect, bought out and made wealthier by virtue of their decision to cease production; under the Orange County system, many small producers are, for practical purposes, taxed out of existence.
>
> In Orange County, the decision to specify groundwater rights In percentage terms causes very different wealth consequences (than in adjudicated basins), but wealth redistribution in the OCWD is no less systematic. Small producers, also with near unanimity, incur transfer payment losses under this management system: Many small producers are simply taxed out of existence; those that survive bear transfer payment losses on 30 to 40 percent of production. Orange County's large water users often either pay no basin equity taxes or pay taxes on perhaps only 3 percent of total water use. Other large producers are explicitly chosen to receive wealth transfers under the BEA program although they may face no incentives whatever to protect the groundwater basin. All large producers in the OCWD benefit from the subsidy to surface water use.

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84 Modifications made this decade in the BEA program allow the Basin Equity Funds to be used for replenishment in addition to surface water subsidization, thus further reducing the wealth transfer since all groundwater producers, regardless of size, benefit from replenishment.

85 Quinn.p. 305.

All groundwater producers benefit from the Orange County Basin's control over groundwater pumping by the savings in extraction costs caused by the raised water table. But for the small producers, this cost savings will be small (per acre-foot of water pumped) compared to the basin equity assessment which is partially determined by the cost of replenishment water. Because the large water users also use more imported water than they do groundwater, they do not have to pay the assessment tax, and in addition benefit from using imported water whose price is subsidized by funds collected from the small producers. Groundwater rents are captured by the largest of groundwater users of the Orange County Basin, with little benefit being received by the small producer.

VI. B. 4. Rent Transfers in the Chino Basin

In the Chino Basin, though three pools of groundwater right holders were created by the basin's water users, only two types of property right holders exist: the overlying landowners, both agricultural and non-agricultural, who cannot transfer their production rights separate from the land; and the nonoverlying landowners or appropriators who are allowed to transfer their rights. From a property rights perspective, appropriators have the advantageous situation because for any individual in that pool, if his value in use is exceeded by the value in exchange, he can sell his groundwater production right and increase his wealth.

Paradoxically, it was the overlying landowners who wanted the restriction on transfers of their production rights. There was a relatively large number of bigger than average producers within the agricultural pool, and production in this pool was dominated by them. Some agricultural users were opposed to transferability of their production rights because transferability would speed the anticipated relocation of rights within the basin towards the appropriators and hasten a decline in the agriculture pool's water use and voting strength.[86] Increased pumping costs from overdraft were affecting both the agricultural pool and the appropriators, but their outlooks for the future varied. Agricultural use was declining while urban use was increasing. The appropriators wanted to avoid the expense of a surface delivery system to meet future needs. Reliance on the basin's storage capacity would allow this, but they wanted the other users of the basin to share in the expense of the plan, and to allow the appropriators to control future management plans.

In the adopted management plan, the agricultural pool benefited by decreased present pumping costs, and the appropriator pool benefited by securing an inexpensive source of future water. Through this agreement reached by the basin's groundwater users, the appropriators would become responsible for paying the costs of replenishment water as their water use increased and as agricultural use declined. But the appropriator pool also benefitted from being able to purchase water no longer used by the agricultural pool. Wealth transfers in the Chino Basin were thus the same as in other basins -- water rights would be transfered from relatively small agricultural users to large urban users.

VII. Summary

This chapter has attempted to show how groundwater management on the South Coastal Plain has not only been able to capture rents for the local groundwater users, but how it has redistributed those rents among the users. The rent-seeking behavior of local groundwater users was initiated by the increase in the value of their groundwater property (albeit common property) by the urban growth of the South Coast Basin which increased willingness to pay for water beyond the cost of groundwater extraction, and by the importation of expensive Colorado River water which created a price differential between groundwater and its closest

[86] Lipson, p. 80.

alternative. The existence of two types of water able to perform the same service, yet with one being cheaper than the other, Imputes an economic advantage or rent to the owner of the cheaper type of water. To capture this rent, the groundwater users established private property rights to the groundwater through adjudication of the production rights.

Adjudication of production rights establishes private property rights to the safe yield of the basin, but property rights to the stock of groundwater in the basin is retained by the groundwater management agency, which is usually a local water district. Preventing entry into the basin by new pumpers, and limiting the present pumpers to the safe yield of the basin, assures the future availability of groundwater and minimizes pumping costs by maintaining the level of the water table. The private property rights to the safe yield are transferable through an exchange pool. The supply of production rights comes mainly from small, agricultural users of the groundwater who are anxious to sell their rights in exchange for cash. The demand for production rights comes mainly from large, urban consumers of water who are willing to purchase the production right because it saves them the expense of meeting all their needs by using imported surface water.

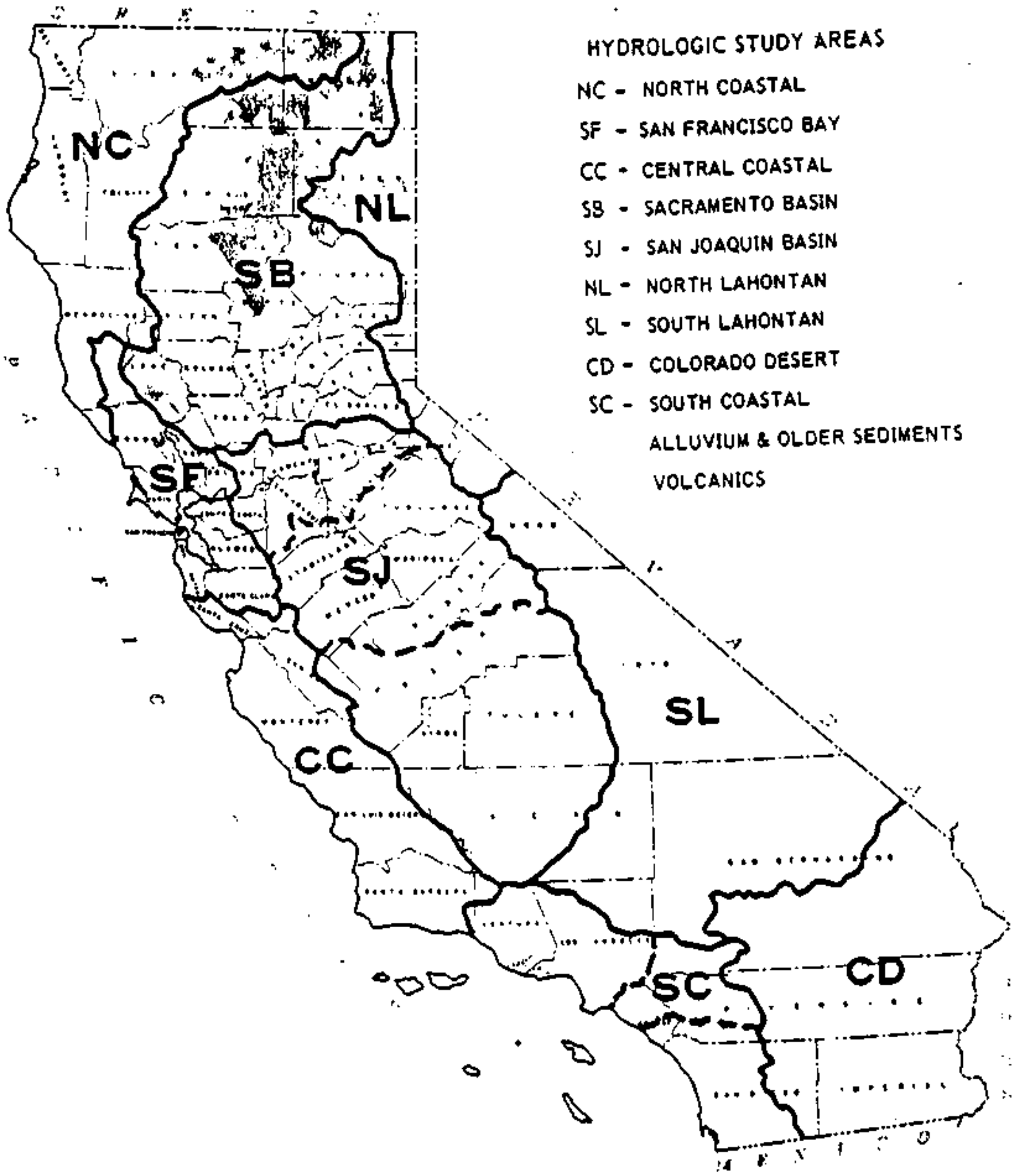
The Orange County Water District has a unique groundwater management program, but it nonetheless conforms to the above rent-seeking behavior. A replenishment assessment equalizes the cost of groundwater with the cost of imported surface supplies, thus eliminating any incentive for new pumpers to enter the basin. The Basin Equity Assessment program was then initiated, transferring the rents from groundwater to the large water users of the basin in the form of a surface water price subsidy. The use of replenishment water is a key component of all groundwater management plans, with the size of the replenishment activity depending upon how easily groundwater is absorbed and dispersed by the basin's hydrodynamic characteristics.

In unmanaged groundwater basins, the groundwater is the common property of anyone who has access to it through a well. If rents exist from the use of groundwater, then groundwater users have an incentive to protect those rents from being tapped by others. The protection of rents from the encroachment of others, and likewise, the capture of rents by oneself, requires that controls be placed upon who can use the groundwater and how much they can use. These controls are established by changing groundwater from the common property to the private property of an individual or group of individuals. The economic incentives caused by rents, stimulates a political response which affects the management of groundwater, i.e. adjudication.

If no rents exist then there will be no management of groundwater. If the economic incentives to institute management are outweighed by political or other considerations, then there will be no management. The next chapters will attempt to measure the economic incentives to manage groundwater in the San Joaquin Valley, and to assess the forces that run counter to these incentives. The experience of the South Coastal Plain will be applied to the situation in the San Joaquin Valley to see if the observed rent-seeking behavior of groundwater users will be motivated.

FIGURE 3-1

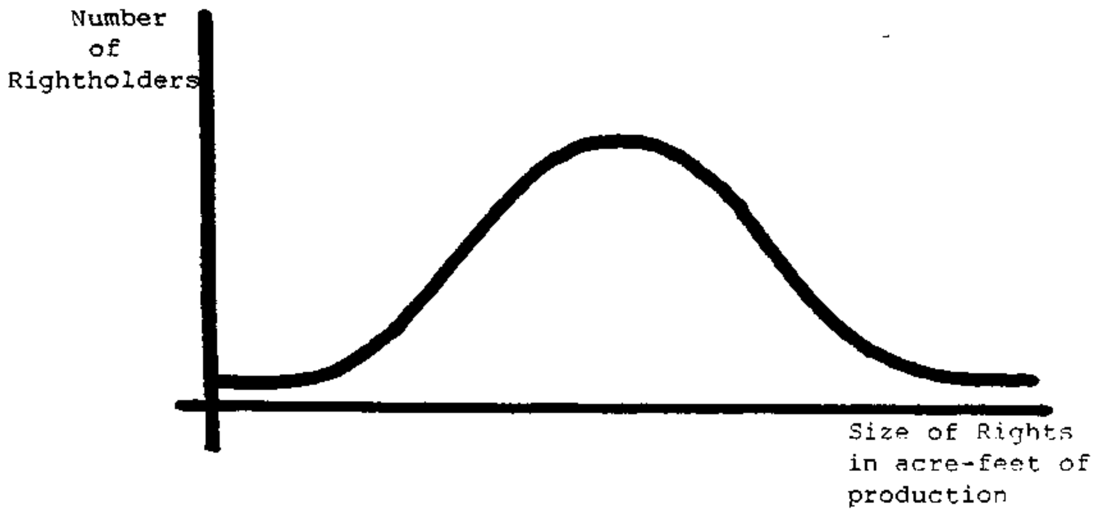
Hydrologic Study Areas in California



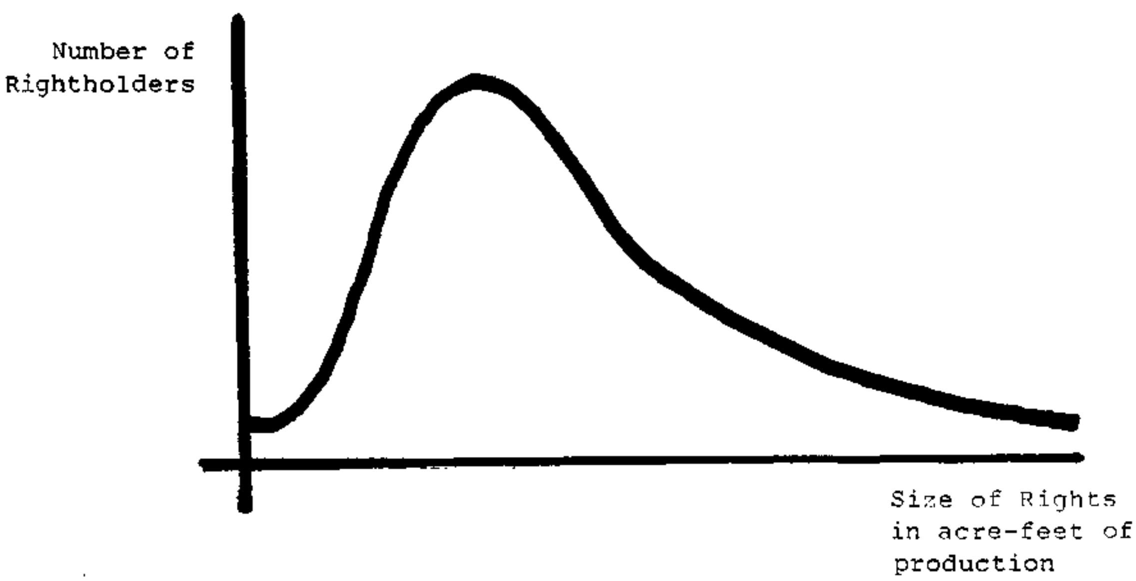
Source: California Department of Water Resources Bulletin 118

FIGURE 3-2

Frequency Distributions



NORMAL DISTRIBUTION



SKEWED-RIGHT DISTRIBUTION

TABLE 3-1:

Characteristics of Groundwater Production Rights in Managed Basins

Basin	Raymond	West Coast	Central	Main S. G.	Chino[1]	Orange[2]
Judgment	1955	1964	1965	1973	1975	1968
Producers	26	117	570	130	462	95
Rights AF	30,622	64,468	217,367	210,000	95,763	
Mean AF	1177.8	552.4	381.4	1615.4	207.3	242.0
Median AF	541.0	32.6	14.0	225.7	87.0	
Std. Dev.	1837.4	1414.1	1903.2	3327.7	474	
Skewness	2.84	3.72	9.10	3.41	8.31	

Source: Quinn, pp. 260 and 261.

[1] These figures apply only to the agricultural pool of the Chino Basin. If the other pools were added, the average production right would be much higher and the standard deviation and skewness likewise.

[2] These figures apply only to the Basin Equity Assessment program which was begun in 1968. The data for the missing values are not available, but it is known that 89.7 percent of the production rights were less than one-third of the basin mean, and only 4.3 percent of the production rights were greater than five thirds of the basin mean, giving the indication of a very strongly positively skewed distribution.

TABLE 3-2

Characteristics of Production Right Transactions[1]

BASIN	Raymond	West Coast	Central	Main San Gabriel
# Producers	26	117	570	130
# Transactions	15	91	460	65
% Active	57.7	77.8	80.7	50.0
% AF	7.5	23.6	12.0	13.3
Net Transactions By:				
smaller than ave.	-1211	-2891	-7491	-12,988
larger than ave.	+1211	+2251	+483	+13,698

Source: Quinn, p. 260,266, and 271.

[1] These figures refer to transactions that include the exchange of production rights as well as the lease of those rights.

TABLE 3-3:

Detailed Characteristics of Buyers and Sellers of Groundwater Production Rights[1]

BASIN	Raymond	West Coast	Central	Main San Gabriel
# Producers	26	117	570	130
# Sellers	6	67	366	28
AF Sold	480	4126	18315	18903
AF Exit/Sale	480	4122	14914	15644
% Exit/Sale	100	99.9	80.9	82.8
# Buyers	3	14	36	11
% 4 Largest	100	78.6	51.8	83.9

Source: Quinn, p. 267, 286, and 300.

[1] These figures refer only to the exchange of productions rights.

CHAPTER FOUR

MEASURING ECONOMIC INCENTIVES TO CHANGE PROPERTY RIGHTS TO GROUNDWATER IN THE SAN JOAQUIN VALLEY

I. Introduction

The preceding chapter has shown that groundwater users are willing to establish institutions which redefine their rights to use groundwater if those institutions protect the rents which accrue to groundwater users. Since Katz v. Walkinshaw[1] in 1903, groundwater users have had correlative rights to groundwater - rights to equal access and equal use of groundwater for all overlying landowners. But in the face of rapid urban development in the South Coast Basin, a new set of rules, established by Pasadena v. Alhambra[2], modified the Correlative Rights Doctrine. This new set of rules allows groundwater users to ask the courts to grant prescriptive rights to those groundwater users who claimed to have used groundwater continuously over the five years previous to the filing of a law suit (i.e. a claim of adverse possession). Prescriptive rights are the most popular form of groundwater right in the South Coastal Plain, yet the means of granting these rights has become more flexible in recent years.

In Los Angeles v. San Fernando[3], the Supreme Court further modified the Correlative Rights Doctrine by ruling that determining rights to groundwater by means other than mutual prescription would not necessarily preclude administration and jurisdiction of those rights by the court to "conserve and apportion water in overdrawn basins." In addition, the court said

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1 Katz v. Walkinshaw, 141 C. 116, 74 P. 766, (1903).

2 City of Pasadena v. City of Alhambra et al., 33 C. 2d 908, 207 P. 2d 17, (1949).

3 City of Los Angeles v. City of San Fernando, 123 C. 3d 1, (1975).

that a determination of the most reasonable and beneficial use of the groundwater is the preferred means of establishing property rights to groundwater as opposed to a simple determination of the quantity continuously used over a five year period. On the South Coastal Plain, efficient management of groundwater basins, which is the goal of establishing property rights to groundwater by adjudication, has been accomplished by the modification of the Correlative Rights Doctrine. (In addition to adjudication of rights to groundwater, groundwater management has been accomplished on the South Coastal Plain by the use of groundwater extraction taxes as in the case of the Orange County Water District.)

Managing groundwater basins by instituting either private property rights or a taxing system is neither instantaneous nor inexpensive. Time and money must be invested to effect a change in groundwater institutions. If such an institutional change occurs, presumably it is because the benefits of such a change outweigh the costs of producing and maintaining it. This chapter addresses the explicit or economic costs and benefits of changing groundwater institutions. Attention will be focused on the San Joaquin Valley where groundwater overdraft is approximately 1.5 million acre-feet a year.[4] A benefit-cost analysis will be used to estimate the incentive for changing groundwater institutions in the San Joaquin Valley by adjudication of groundwater property rights. The net present value from use of the groundwater resources of the Valley will be computed under two alternative institutional structures -- the present common property institution (as exists under the Correlative Rights Doctrine) versus an alternative set of rules called optimal control.[5] Groundwater

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[4] California Department of Water Resources, California Water: Looking to the Future, Bulletin 160-87, Sacramento: Department of Water Resources, 1987, p. 32.

[5] Use of groundwater over time will provide to its users a stream of income. Income in all future periods is the excess of total value over total costs from the use of groundwater. Net present value of groundwater use is determined by discounting to the present all future incomes from a given rate of groundwater use, and then summing these discounted future incomes. Discounting is a means of valuing future incomes in terms of present income by applying to future incomes a discount factor (equal to (1 + r) - t where t is the future time period and r is the rate of interest).

extractions under optimal control are assumed not to differ significantly from the pattern of extraction created by the establishment of private property rights to groundwater,[6] If the net present value of groundwater use under common property is less than the net present value of the groundwater use under optimal control (by an amount that exceeds the best of instituting property rights), then there will be an economic Incentive? to change to the latter set of rules governing access and use of groundwater.

Though an economic incentive to change groundwater institutions may exist, two barriers may prevent the change in institutions from occurring. First, the cost of undertaking the change may outweigh the gains received after the change is made. In economic terms, there may be transactions costs that prevent the attainment of a Pareto-superior outcome.[8] Second, though an aggregate increase in income means a group as a whole may benefit from an institutional change, the distribution of the increased income may encourage individuals within the whole to fight against the institutional change.[9] An institutional change

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6 Limiting of groundwater extractions under the optimal control model does not limit extractions to the steady state amount, but rather extractions follow a path from the present extraction amount to the steady state amount. This optimal control path typically will be a smooth transition from one state (the initial state) to another state (the steady state), as opposed to a bang-bang path where the movement from the initial state to the steady state is as rapid as possible.

This economic incentive arises because the optimal control institutions are more efficient than the common property institutions. This increased efficiency means the use of groundwater under the former rules will provide the groundwater users with a greater amount of income. The increased income, irrespective of distributional issues, motivates the groundwater users to adopt optimal control institutions. This income, because it is due to the use of a natural resource in limited supply, is also called rent.

8 In a world of perfect markets, free information, and costless and instantaneous transactions, the economist's policy goal is a Pareto-optimum -- an allocation of resources wherein no one can be made better off without someone else being made worse off. Rather than ascertaining whether a particular institutional structure is Pareto-optimal, this dissertation only addresses whether one institution performs better or worse than another (i.e. is Pareto-superior). The measure of performance is the net discounted present value of income (rent) derived from use of a resource.

9 This problem is called the Problem of Large Numbers. See Mancur Olson, The Logic of Collective Choice. Cambridge: Harvard University Press, 1965.

may cause a change in the distribution of benefits and costs across individuals which may disadvantage some while advantaging others (i.e., a winner under one institutional structure may become a loser under another). This chapter ends with a look at the first barrier to realizing institutional change: the costs of adjudicating groundwater rights-in the San Joaquin Valley. The following two chapters look at the groundwater users in the San Joaquin Valley to discern the distribution of costs and benefits across the users and how this distribution might be a barrier to institutional change.

II. Introduction to the Economics of Groundwater Use

The San Joaquin Valley consists of nearly 8.5 million acres, of which 4.5 million acres are irrigated. Rich soil, a warm climate, and irrigation water have combined to make the San Joaquin Valley the nation's most productive agricultural area. Irrigation water comes from four main sources; nearly 50,000 groundwater wells found throughout the Valley which are privately owned, locally financed surface water diversions which are concentrated in the east-central portion of the Valley, the State Water Project which supplies water imported from the northern part of the state to lands on the western and southern slopes of the Valley, and the federal government's Central Valley Project operated principally by the Bureau of Reclamation which supplies surface water to the full length of the eastern side of the Valley. Total water use in the Valley is nearly 13.5 million acre-feet annually of which over 90 percent is for agriculture.[10]

[10] John R. Teerink and Burt A. Babcock, "Ground Water Economics in the San Joaquin Valley," in Economics and Groundwater, edited by Donald Finlayson, New York: American Society of Civil Engineers, 1984, p. 30.

Of the above water supplies, nine million acre-feet per year or nearly two-thirds is groundwater.[11] Of this 9 million acre-feet of groundwater, 1.5 million acre-feet, or 16 percent, is from overdraft of the groundwater basin. Overdraft of a basin is a condition wherein the amount extracted exceeds the amount entering the basin. Groundwater extraction, or the demand on the groundwater resource, by the nearly 50,000 wells is scattered throughout the valley. Water entering the basin, or the supply of the groundwater resource, comes from: excess precipitation; seepage from municipal, industrial, and recreational uses; seepage from natural streams, canals and aqueducts; intentional recharge of excess surface water; subsurface inflows from adjacent basins; and most importantly from irrigation percolation. The western half of the aquifer underlying the San Joaquin Valley basin is capped by an impermeable layer of clay which prevents most of the above sources of return flow from replenishing the basin.

The demand for groundwater in the San Joaquin Valley is a "derived demand." Irrigators are willing to pay a price for water because they receive a benefit from using it. This benefit is the revenue collected from the sale of the agricultural products produced with the water. The price they are willing to pay for an acre-foot of water, called a demand price, is determined by the productivity of that acre-foot of water and by the price of the output it produces. Across different crops, both the productivity of an acre-foot of water and the price of the output can vary, but in general for any particular crop, the amount of groundwater an irrigator will want to use will increase as the demand price of groundwater decreases (and the amount he will want to use will decrease as the demand price of groundwater increases).

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[11] For the state as a whole, total water use is 40.6 million acre-feet per year, with groundwater supplying 16.5 million acre-feet per year, or 41 percent. See Raymond H. Coppock, Robert M. Hagan, and William W. Wood, Jr., "Introduction: The Problem, the Resource, the Competition," in Competition for California Water - Alternative Resolutions, Edited by Ernest A. Engelbert, Berkeley: University of California Press, 1982, p. 4.

The above relationship between the amount of groundwater demanded and the demand price can be viewed from a quantity dependent or from a price dependent point of view. From a price dependent point of view, for each acre-foot of groundwater there is a particular price which an irrigator will be willing to pay, which is to say that each quantity of groundwater has a certain value to the irrigator. This value, called the value of marginal product, is derived from multiplying the addition to total output of the added acre-foot of water (or the marginal product of each acre-foot of water) times the market price of the output which the added acre-foot of water produced. [12] From a quantity dependent point of view, the same pairing of each acre-foot of groundwater to the value of marginal product is called a demand function for groundwater and differs from the value of marginal product function only in its cause-effect relationship.[13] A demand function for groundwater gives the amount of groundwater demanded as a function of the price per acre-foot of groundwater.

In addition to the demand for groundwater, two important factors affecting actual use of groundwater are the availability of surface water and the extraction cost of groundwater (the latter of these being equivalent to a supply function for groundwater). In a wet year when precipitation and surface water are abundant, an irrigator will need to use less groundwater than in a normal year; and if it is a drought year, then an irrigator will need to use much more groundwater. By buffering shortfalls in surface water availability, groundwater provides perhaps its greatest service to the irrigator. Surface water developments such as the State

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[12] This assumes that the product market is perfectly competitive. See P. R. 6. Layard and A. A. Walters. Microeconomic Theory. New York: McGraw-Hill Book Co., 1978, p. 259. The assumption of perfect competition in both the product and factor markets will be carried throughout this chapter.

[13] A price dependent relation in linear form would be P=a-bW, whereas the quantity dependent relation is W=c-dP, where W is acre-feet of groundwater, P is price per acre-foot of groundwater, and a,b,c and d are arbitrary constants. In both equations, P and W are inversely related, except that the first statement says the price people are willing to pay for additional Quantities of water is falling, and the second statement says that the quantity of water that will be demanded will increase if the price of water falls.

Water Project and the Central Valley Project have greatly reduced the variability of irrigation water to the irrigator, but as during the 1976-77 drought when surface water supplies were very low, groundwater pumping kept thousands of acres of irrigated land in production and hundreds of irrigators in business.

Extraction costs of groundwater are determined by the physical abundance of the groundwater resource, and by the irrigator's technique of extraction. This technique of extraction has two components which will be treated separately: a physical component represented by the type of wells, pumps, and energy used to draw the water from below ground, and an institutional component which determines how each irrigator reacts to the interdependency caused by their joint use of a scarce resource. Groundwater lies at particular depths below the surface of the land. The deeper a well must be driven to reach the groundwater, the greater the cost per acre-foot of groundwater extracted. The increased extraction costs are due to the costs of deeper drilling, of increased pipe-length to reach between the surface and the groundwater, of a stronger pump to raise the water from the lower depth, of increased maintenance, etc., and most importantly, of increased energy to run the pump. Because each component of the extraction cost of groundwater is a function of the depth to groundwater, so too is the extraction cost of groundwater dependent upon the depth to groundwater. The greater the depth to groundwater, the greater the extraction cost of groundwater.

From year to year the depth to groundwater may change. If every year the amount of water entering the basin is equal to the amount of water exiting the basin, then there would be no change in the depth to groundwater. If the amount of groundwater extracted from a basin exceeds the amount of water replenishing the basin, the depth to groundwater will increase, and the basin is said to be in a condition of overdraft. If the amount of inflow into a basin exceeds the amount of outflow, then the depth to groundwater will decrease. The actual change in the depth to groundwater caused by any given difference between the basin's rate of inflow and the rate of outflow also depends upon the size of the basin.

As a very simplified example of the relationship between the size of a basin, the change in volume of groundwater in the basin, and the change in the depth to groundwater, a groundwater basin can be though of as a box with four sides, a bottom, and a top, the last of which is the surface of the land.[14] If the box is two feet square on all sides, and if there are six cubic feet of water in the box, then the water lies six inches below the top of the box. If one-half cubic foot of water enters the box then the depth to the water becomes only 4.5 inches, and subsequently if one cubic foot of water is removed from the box, then the water falls to 7.5 inches below the top of the box. The box can be said to be subject to an overdraft condition since the net change in volume of water in the box has been minus one-half cubic foot, leaving the box with 5.5 cubic feet of water instead of the initial 6 cubic feet, and causing the distance between the water and the top of the box to increase by 1.5 inches to 7.5 inches from the previous six inches. The process of adding one-half cubic foot and extracting one cubic foot can be continued only 11 times before the box is emptied of its water.

A unit of groundwater will be extracted only if the cost of extracting groundwater, determined by the depth to the groundwater, exceeds the value of the marginal product of that

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14 Groundwater basins can have very complex physical dimensions. Differences in density or porosity of soil, in fault lines or other boundary parameters, in distances between the surface and the aquifer, and in other variables serve to make no two groundwater basins exactly alike. Depending upon these physical characteristics, groundwater will flow through a basin at varying speed and direction. These physical differences lead to different economic characteristics of various basins, and to the economic conditions of groundwater users. An advantageous location of one groundwater user as compared to another can make the former wealthier than the latter because of the greater rent he would accrue due to the advantages of his location. Furthermore, human action serves to differentiate basins in physical and economic terms. For example, groundwater extractions concentrated at one point in a basin will cause a cone of depression which makes the distance between the surface and the water in the aquifer of even greater distance, and a cone of depression may be deep enough to reverse the flow of the groundwater in an aquifer. A cone of depression has wealth-depressing consequences for the groundwater users located above it.

unit of groundwater. Changes in the depth to groundwater, which cause changes in the cost of extracting groundwater, will change the actual amount of groundwater used. Changes in the depth to groundwater are created by an imbalance between the amount of recharge to a basin and the amount of groundwater extraction. The amount of recharge is dominated by physical considerations such as rainfall and porosity of the soil, but the amount of groundwater extracted is the result of human behavior, and is, therefore, the controlling variable in the balance between the physical forces that raise and lower the depth to groundwater.

The efficient amount of groundwater to be extracted is determined by economic forces such as the value of marginal product and marginal extraction cost of the extracted groundwater. In addition to the economic forces, there are institutional forces that affect the amount of groundwater which individuals decide to extract. In particular, these institutional forces are created by the property rights structure that governs the relationships between individuals who use groundwater. These institutional forces affect the decision makers perception or measurement of the value of marginal product or marginal extraction cost of groundwater, and determines whether the amount extracted is economically efficient or not.

Because groundwater is a fluid and fugitive resource, extraction of groundwater in the vicinity of one well will in general cause a lowering of the groundwater table in areas beyond the vicinity of that well. Each irrigator's groundwater extractions cause the depth to groundwater to fall for himself <u>and</u> for every other individual who has access to the groundwater. The institution of common property rights does not allow exclusion of others from the use of groundwater. Without exclusion, individuals need not account for the increased extraction costs they imposed on others. Because common property rights do not recognize the physical interdependence among users of the common resource, an economic interdependence[15] is created whose solution calls for an institutional response in terms of established exclusive property rights among those who use the common resource.

The existing set of property rights with respect to groundwater in the San Joaquin Valley is called common property. Under common property, the physical and economic interdependency caused by all groundwater users pumping from the same basin is ignored by all who create it. This interdependency has a physical genesis and an economic consequence, but it is because of the institutional arrangement of common property rights between the users of the resource that the economic interdependency does not enter into the groundwater use decision made by the users of the resource.

Over the course of a year, if an imbalance between the amount of groundwater which replenishes the aquifer and the amount of groundwater extracted causes a basin to be overdrafts, then the height of the water table will be lower in the next year than in the current year. The costs of pumping from the lowered water table are incurred in future years rather than in the current year,'[16] though it is the rate of groundwater extraction in the current year which produces the lowered water table in the future years. For the basin's

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[15] Such an economic interdependence is an externality as defined by Baumol and Oates. In their definition, two conditions must be met for an externality to exist: (1). an externality is present whenever some individual's production relationships include real variables, whose values are chosen by others without particular attention to the effects on his welfare, and (2). the decision maker, whose activity enters their production functions, does not pay compensation for this activity in an amount equal in value to the resulting marginal costs to others. See William J. Baumol, and Wallace E. Oates, The Theory of Environmental Policy. Englewood Cliffs: Prentice-Hall, Inc., 1975, pp. 17-18.

[16] For example, suppose the water table is twelve feet below the surface, and that the amount of recharge into and extraction out of the basin are constant every year such that recharge into the basin causes the water table to rise by five feet each year, but extraction causes the water table to drop by six feet each year. In the first year, water will be pumped from a depth of twelve feet, but in the second year the depth falls to thirteen feet (one foot lower because of the first year's extraction rate); in the third year the depth falls to fourteen feet (two feet lower than in the first year - one foot lower because of the second year's extraction rate and one foot lower because of the first year's extraction rate); in the fourth year the depth falls to fifteen feet (three feet lower than in the first year - one foot lower because of the third year's extraction rate, one foot lower because of the second year's extraction rate, and one foot lower because of the first year's extraction rate); etc.

groundwater users as a whole, the increased costs from overdraft of groundwater (i.e., greater future extraction costs) may be outweighted by the benefits (i.e., increased wealth from the sale of the output produced with groundwater or from the sale of groundwater itself). The quantity of overdraft for which the marginal cost of overdraft equals the marginal benefit of overdraft would be the optimal amount of overdraft for the basin.

The lowering of the groundwater table today (caused by overdraft) means the cost of groundwater extraction will be raised tomorrow. The efficient irrigator will be the one who takes these future costs (called user costs) into his present-year decision on how much to extract, with the result being an optimal amount of extraction. However, given the fugitive nature of groundwater and a groundwater basin with more than one overlying landowner, extraction by any one irrigator also affects all other users of the same basin. Present year extractions by one irrigator not only affect his future extraction costs but the costs of all other irrigators, because the groundwater table is lowered for all irrigators when any one of the extract groundwater from the basin. If all individuals ignore these costs they inflict upon others, as is done under common property rights, then the amount of groundwater extracted and the amount of overdraft in the basin will be greater than the optimum amount.

Under common property rights any single groundwater user will undervalue the costs of his extraction because he will neglect the effect his groundwater extraction decision has on the future extraction costs of others who extract groundwater from the same basin. The institution of common property causes all individuals to make myopic economic decisions. If the future increases in extraction costs were not ignored, it does not mean that future cost increases would not exist, because the non-common property rate of extraction may still exceed the rate at which water replenishes the basin, [17] but those future increases in extraction costs will be less. The myopic or common property rate of extraction will be greater than if one individual was the sole owner of the basin's groundwater or if he were one of many who were all required (as by the institution of private property rights) to take into consideration the costs which his actions inflict upon others.

The benefit from slowing today's rate of extraction is the lowered increase in the future cost of extraction. Under myopic economic decision rules, this benefit is ignored. In economic terms, the myopic decision rule causes the individual to extract groundwater until the value of marginal product equals the private cost of extracting the additional acre-foot of groundwater. However, the social marginal extraction costs are greater because of the physical interdependencies among users of the common aquifer. Other groundwater extractors bear costs from excessive rates of extraction, and these costs are not taken into consideration in individual private marginal cost calculations (i.e. an externality exists). If institutional arrangements existed which required each individual extractor to take these costs into consideration (i.e. exclusive property rights), then the amount used would be increased only as long as the value of marginal product from use exceeded the social marginal extraction costs. The result of such property rights is that the amount used by each and all extractors would be less, and the reward for using less is a less rapid increase in future extraction costs and higher future profits.

The question to be answered in this chapter is why would the users of the groundwater desire to change from one set of property rights to another? The answer lies in comparing the net present value of groundwater use under the two alternative property rights institutions.

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[17] If the value of marginal product of the applied groundwater exceeds the sum of the future increases in extraction costs, then it would be efficient to use groundwater, even if it meant the basin was overdrafted. As use continued, the value of marginal product would fall, and the sum of the future increases in extraction costs would rise, until they equalled each other, at which point continued extraction would cease.

That institution with the highest net present value is the economically preferred one for the users of the groundwater resource to adopt because their wealth from groundwater use will be larger. The following model provides a means of comparing the net present value of the groundwater resources of the San Joaquin Valley under common property (using the myopic economic decision rule) and under an alternative property rights structure which will be called optimal control. Under optimal control, the social marginal user cost of extracting a present acre-foot of groundwater is included in the decision-making process of the individual irrigator.

III. Introduction to the Model[18]

Differences in income that accrue to groundwater users exist because of different rates of groundwater use. Different rates of groundwater use can be due to differences in property rights to groundwater, irrigators will be assumed to use groundwater at a rate that is consistent with maximizing the present discounted value from groundwater use, given the

18 This model is based upon work spanning nearly a decade by Micha Gisser in the Department of Economics at the University of New Mexico. See Micha Gisser and Abraham Mercado, "Integration of the Agricultural Demand Function for Water and the Hydrologic Model for the Pecos Basin." Water Resources Research 8. (Dec. 1972) pp. 1373-1384; Micha Gisser and Abraham Mercado, "Economic Aspects of Ground Water Resources and Replacement Flows in Semiarid Agricultural Areas," American Journal of Agricultural Economics 55. (Aug. 1973), pp. 466-461; Micha Gisser and David A. Sanchez, "Some Additional Economic Aspects of Ground Water Resources and Replacement Flows in Semi-Arid Agricultural Areas," International Journal of Control 31.2. (1980), pp. 331-341; and Micha Gisser and David A. Sanchez, "Competition Versus Optimal Control in Groundwater Pumping," Water Resources Research 16. 4. (Aug. 1980), pp. 638-642. The model has also borrowed some ideas and most of its data from a simulation model developed by the California Department of Water Resources, which like the Gisser and Sanchez (1980) model is able to compare extraction rates, height of water table, and present discounted value of income for different extraction rates. See California Department of Water Resources, The Hydrologic-Economic Model of the San Joaquin Valley, Bulletin 214. December. 1982; California Department of Water Resources, Final Report The Hydrologic-Economic Model of the San Joaquin Valley. Appendix C, San Joaquin Valley Hydrologic-Economic Modeling Study, Bulletin 214, prepared by Jay E. Noel and Dennis McLaughlin, Dec. 1982; and Marangu Marete, "San Joaquin Valley Hydrologic-Economic Model," in Economics and Groundwater. edited by Donald Finlayson, New York: American Society of Civil Engineers, 1984.

existing property rights institution.[19] Though the level of the present discounted value depends upon rates of groundwater use, different use rates can result from different institutions under which the use rate decision is made. Indirectly, the level of present discounted value that results from groundwater use depends upon the institutional choice made by the groundwater users.

In this model the present value maximizing rate of use is calculated using the optimal control rate of use. All other rates of use, particularly that rate associated with the institution of common property, will be said to be inefficient, or Pareto-inferior. Because the common property rate of use is inconsistent with the present value maximizing rate of use, there is an "externality" associated with the former rate of use. Caused by the institution of common property, an externality manifests itself as the increases in future extraction costs which are ignored by the irrigators who pump groundwater at the common property rate of extraction. Because any difference in the present discounted value of groundwater use is

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19 For examples of applying the present discounted value technique to the use of groundwater, see M. M. Kelso, "The Stock Resource Value of Water." Journal of Farm Economics 43, (Dec. 1961), pp. 1112-1129; Oscar.R. Burt, "Optimal Resource Use over Time with an Application to Ground Water," Management Science 80, (1964), pp. 80-93; Oscar R. Burt, "Economic Control of Ground Water Reserves," Journal of Farm Economics 48, (Dec. 1966), pp. 632-647; Oscar R. Burt, "Temporal Allocation of Ground Water." Water Resources Research 3, (First Quarter 1967), pp. 45-56; Oscar R. Burt, "Groundwater Management under Quadratic Criterion Functions," Water Resources Research 3, (Third Quarter 1967), pp. 673-682; John D. Bredehoeft and Robert A. Young, "The Temporal Allocation of Ground Water - A Simulation Approach." Water Resources Research 6, (Feb. 1970), pp. 3-21; R. G. Cummings, and D. L. Windelman, "Water Resources Management in Arid Environments," Water Resources Research 6, (1970), pp. 1559-1568; M. G. Brown, and R. Deacon, "Economic Optimization of a Single-Cell Aquifer," Water Resources Research 8, (1972), pp. 557-564; M. Gisser, and A. Mercado, "Economic Aspects of Ground Water Resources and Replacement Flows in Semiarid Agricultural Areas," American Journal of Agricultural Economics 55, (1973), pp. 461-466; R. G. Cummings, and J. W. McFarland, "Groundwater Management and Salinity Control," Water Resources Research 10, (1974), pp. 909-915; O. R. Burt, R. G. Cummings, and J. W. McFarland, "Defining Upper Limits to Groundwater Development in the Arid West," American Journal of Agricultural Economics 59, 5, (Dec. 1977), pp. 943-947; M. Gisser and D. A. Sanchez, "Some Additional Economic Aspects of Ground Water Resources and Replacement Flows in Semi-arid Agricultural Areas," International Journal of Control 31, 2, (1980), pp. 331-341.

Imputed to different institutional arrangements under which groundwater use rates are made, this difference is the measure of the cost of not adopting the present value maximizing institution.

To infer an incentive for institutional change, the model developed below will compare the income earned from groundwater use under common property rates of use with the income derived from groundwater use when the rate of use is tempered by exclusive property rights. The latter figure will be derived using optimal control or dynamic programming methods as developed by Pontryagin[20] and formally applied to economic problems by Arrow and Kurtz.[21] Problems such as excess salinity[22] and land subsidence[23] may also be caused by inefficient rates of groundwater extraction, but these problems are not addressed in this model, though their problem definition as externalities and their solution by institutional change are closely related to the problem of common property that is addressed here.

The key step to determining the income from both common property and private property rates of groundwater extraction is the connection made between the economics of groundwater use and the physical consequences of the rate of extraction. Any given rate of groundwater extraction will provide a flow of benefits from the production and sale of output grown with the groundwater. Any rate of extraction will have associated with it a cost for extraction due to the labor, capital, and energy used to pull the groundwater to the surface.

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[20] See L. S. Pontryagin, V. G. Boltyanshii, R. V. Gamkrelidze, and E. F. Mischenko, The Mathematical Theory of Optimal Processes, New York: Interscience, 1962.

[21] See Kenneth J. Arrow and Mordecai Kurtz, Public Investment, the Rate of Return, and Optimal Fiscal Policy, Baltimore: The Johns Hopkins Press for Resources for the Future, 1970.

[22] See R. G. Cummings and J. W. McFarland, "Groundwater Management and Salinity Control," Water Resources Research 10, (1974), pp. 909-915; and James W. McFarland, "Groundwater Management and Salinity Control: A Case Study in Northwest Mexico," American Journal of Agricultural Economics 57, 3, (1975), pp. 456-462.

[23] See John P. Warren, Lonnie L. Jones, Donald D. Lacewell, and Wade L. Griffin, "External Costs of Land Subsidence in the Houston-Bay town Area," American Journal of Agricultural Economics, v. 57, no. 3, 1975, pp. 450-455.

Also, the rate of extraction will affect the groundwater basin by lowering the water table, the amount of the lowering from any given rate of extraction dependent upon physical characteristics of the basin. The economic and physical aspects of groundwater use are interconnected because the rate of extraction affects the depth to groundwater, and the depth to groundwater determines the cost of extraction, and the cost of extraction affects the rate of extraction chosen by the profit-maximizing users of the basin. This interconnection between the economics of groundwater use and the physical behavior of the basin will be developed immediately below.

III. A. Common Property Equations

The demand for groundwater is a derived demand[24] which can be written as

$$W = g - kP \tag{1}$$

where g is the groundwater used (W) when the price (P) is zero, and k is the change in water use when the price increases by one dollar. For computational convenience, a simple linear demand function is assumed. This equation says that the amount of groundwater demanded will decrease, all other things equal, as the price an irrigator must pay for groundwater increases. The price the irrigator must pay for groundwater is the extraction cost per acre-foot, or the marginal cost of production. The marginal cost of production will be shown to be a function of the depth to groundwater, or equivalents a function of the height of the water table, and so the amount of groundwater used will also be a function of the height of the water table.

24 The demand for water, or its value of marginal product, depends upon many factors such as the type of crop grown, the number of rotations of the crop within the growing season, the price for which the crop sells, the other inputs used in conjunction with water, and other physical and economic and institutional variables. A linear demand function is assumed to adequately expresses the relationship between the amount of water demanded and the price irrigators are will to pay. Later in the model the demand function is said to hold for a particular area under study (a detailed analysis unit (DAU) which is a specific geographical section of the San Joaquin Valley). The demand function will remain fixed as long as the above factors which determine the value of marginal product do not change.

The use of groundwater is for irrigation of agricultural crops. The benefit of using irrigation water is the value of the additional crops which it produces. According to the Law of Variable Proportions, additional quantities of applied groundwater will add less and less to total output. If the market price of output is assumed constant, then the total value (TV) from using increasing quantities of groundwater will have the general shape as drawn in Figure 4-1. The slope of the TV curve is everywhere declining, and is used to derive the value of marginal product curve.

The cost of utilizing groundwater is the sum of the costs of pumping the water to the surface, conveying it to the point of use, and applying it to the crop to be irrigated. It will be assumed that in the short-run, the per unit cost of power, pumps, pipes, etc., and the per unit costs of installing the irrigation technology needed for accessing the groundwater are a constant function of the quantity of water extracted. So long as any one irrigator is small in relation to the size of the aquifer so that his pumping does not lower the height of the water table by a measurable amount, then the irrigator will treat the per unit cost of groundwater as a constant. As a function of the amount of water used per unit of time, the total cost of water (TC) can be graphed as in Figure 4-1. TC is linear and its slope is the average and marginal cost (MC). For any given depth to groundwater, the marginal and average cost per acre-foot of groundwater will be a constant. If the depth to groundwater increases, then so will the marginal and average cost per acre-foot of groundwater extracted.

The above linear cost function 25 suggests that the marginal cost of an acre-foot of groundwater (MC) is an increasing function of the depth to groundwater (D)

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25 see P. A. Domenico, D. V. Anderson, and C. M.Case, "Optimal Groundwater Mining." Water Resources Research 4. 2, (1968), pp. 247-255; and W. E. Martin, and T. Archer, "Cost of Pumping Irrigation Water in Arizona: 1891 to 1967." Water Resources Research 7. 1, (1971), pp. 23-31. The cost function being assumed here is TC = a + cDW, where 'a' is some constant (which could be zero) representing fixed cost for an acre feet of groundwater and where variable costs are cDW.

$$NC = cD \tag{2}$$

where c is a cost per acre-foot of groundwater per foot of depth. The cost per foot of depth, c, includes all labor, capital, energy, etc. costs necessary to bring an acre-foot of water one foot closer to the surface. The marginal cost of production per acre-foot of groundwater as given in this equation is a long-run marginal cost function. Writing depth as the difference between the elevation of the ground (E) and the height of the water table (H), this function can be made a function of the height of the water table:

$$\begin{aligned} NC &= C(E-H) \\ &= cE - CH \\ &= f - cH. \end{aligned} \tag{3}$$

In this equation f [26] represents an increment to marginal cost that is not a function of the height of the groundwater table (H), and as before, c is the cost per acre-foot per foot of lift. Notice that as the height of the aquifer increases, the marginal extraction costs decrease.

When the users of groundwater are also assumed to be the producers of the groundwater, as is the case in the San Joaquin Valley where 90 percent of all wells are privately owned and used for supplying groundwater to crops when surface water is not available, the user will "sell" the groundwater to himself at a price per acre-foot equal to the marginal cost of production. The farmer will use groundwater up to the point where the value of marginal product equals the marginal cost of water. The cost of extracting groundwater per acre-foot to the irrigator is the marginal cost of production. The price P in equation (1), the derived demand function, can be set equal to the marginal cost of production showing that the

[26] If H=0 then MC=f, so that f represents the cost of extracting water from a depth of sea level. Sea level has no particular importance puts acts as a benchmark similar to a temperature of 0° Fehrenheit. Also note that if the basin is completely full so that there is an artesisnwell (i.e., H=E)then the marginal cost of extraction is zero.

price the irrigator is willing to pay for groundwater is the value of marginal product. Hence we can write P=MC in equation (3), or

$$P = f - CH \tag{4}$$

thus simplifying the notation by referring to the marginal cost of production as P -- the price the irrigator is willing to pay for the groundwater.

As exploiters of a common groundwater basin under the institution of common property, all users of the basin ignore the costs that their individual extractions have on the other users of the basin. All users of the basin equate the value of marginal product to the marginal cost of production when making their pumping decision. This is the myopic economic decision rule which ignores the increased future extraction costs from present rates of extraction. Substituting the marginal cost of production function, $P = f - cH$ in equation (4).into the demand for groundwater function, $W = g - kP$ of equation (1), yields a function that describes common property groundwater use as a function of the height of the water table. This function relates the economic behavior of the users of the basin to a physical characteristic of the basin:

$$\begin{aligned} W &= g - k(f - cH) \\ &= (g - kf) + ckH \\ &= d + ckH. \end{aligned} \tag{5}$$

When the above equation, based upon the economic behavior of the users of the basin, is combined with an equation describing the dynamic behavior of the groundwater basin, the necessary connection between the economic and physical systems will have been made and this will lead to a determination of the net present value of groundwater use.

The height of the basin's water table will rise as water replenishes the basin and will fall as water is extracted from the basin. It is possible to translate the difference between the incoming volume of water and the outgoing volume of water into changes in the height of the water table ($\dot{H}$, which is the change in the height of the water table per unit of time, or dH/dt[27]). The total volume of water in any basin can be measured by taking the area of the aquifer (A) times the height of the water table (H) times the storativity coefficient of the water-bearing formation (S).[28] (The storativity coefficient measures the percentage of water which can be found in a volume of soil. Soils will vary in their ability to absorb and release water, and the greater the storativity of the aquifer, the more water will be found in any given volume of soil.)

The amount of water that flows into the acquifer, from natural and artificial recharge, and from return flows due to transportation and use of surface water, is designated by "R". This inflow component of the aquifer's behavior is assumed constant every year though it is actually stochastic. The value for R is an average of the flows during the relatively normal water years between 1970 and 1975, and the model's deterministic analysis will yield results that are appropriate for average or steady state conditions. Large new surface water delivery projects would increase the inflow into the aquifer, making the assumption of a constant inflow inappropriate (by permanently raising the average), but important changes in the overall water availability picture are assumed not to happen during the period over which the model is applied.

The Mamount of water that flows out of the aquifer, or the consumptive use of extracted groundwater, is given by aW, where a is the percent of extracted groundwater that is consumptively used and does not return to the basin. The change in the height of the water

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[27] $\dot{H}$ or dH/dT is a time derivative of the height of the water table.

[28] The volume of soil in the water-bearing portion of the basin is given by AH. The volume of water in the above volume of soil is ASH. Changes in the water volume will cause changes only in the height of the water table, since both A and S are constants.

table over time ($\dot{H}$), caused by the difference between the inflow and the outflow of water, is described as follows:

$$ AS\dot{H} = R - aW $$

$$ \dot{H} = \frac{R - aW}{AS} \qquad (6) $$

These two versions of the same equation offer different interpretations of water's behavior within an aquifer. The first version is simply a statement requiring conservation of matter, saying that the change in water volume ($AS\dot{H}$) is due to the difference between the volume of water entering the basin (R) and the volume of water leaving the basin (aW). The second version says any change in the height of the water table is due to the difference between the height increases caused by recharge (R/AS) and height decreases caused by extraction (aW/AS). This equation for $\dot{H}$, describing the dynamics of the basin, and equation (5) describing groundwater use as a function of the height of the water table (W=f+ckH) will be used to determine the time paths of the height of the water table, the rate of groundwater extraction, and the flow of income from that rate of extraction.

By substituting d+ckH for W in equation (6), a first order differential equation is formed as follows:

$$ \dot{H} = \frac{R - a(d + ckH)}{AS} $$

$$ \dot{H} = \frac{R - ad}{AS} - \frac{ack}{AS} H \qquad (7) $$

The solution to this differential equation[29] is

$$H(t) = \frac{R - ad}{ack} + [H_0 - \frac{R - ad}{ack}] e^{-\frac{ack}{AS}t} \tag{8}$$

where H(t) is the time path of the height of the water table - an equation that gives the height of the water table at any given point in time.

The above solution to a differential equation has the standard form of

$$H(t) = H_{SS} + [H_0 - H_{SS}] e^{-xt} \tag{9}$$

where $x = ack/AS$, H_{SS} is the steady state value of the height of the water table, H_0 is the initial or current height of the water table, and the exponent (xt) governs the path from the present height to the steady state height. (For the system to be stable or to approach the steady state rather than diverging from it, the exponent (ack/AS) must also be positive). When t=0 then $H(t) = H_{SS} + (H_0 - H_{SS}) = H_0$ and as time approaches infinity, H(t) approaches H_{SS}. H_{SS} is the height of the water table which will be maintained by groundwater users so as to maximize profits from groundwater use. Note that its value depends upon both physical parameters (total return flow into the basin (R) and the percent of groundwater extracted which is consumptively used (a)) and economic parameters (the slope of the demand function (d), the cost per acre-foot per foot of depth (c), and a variable (d = g-kf) which takes into consideration the intercept of the demand function, the intercept of the marginal cost function, and the slope of the demand function). The time path H(t) begins at the initial

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[29] For the solution technique see Morton I. Kamien and Nancy L. Schwartz, Dynamic Optimization: The Calculus of Variations and Optimal Control in Economics and Management, New York: Elsevier North Holland, 1981, Appendix B, Section 2; and p. 639 Micha Gisser and David A. Sanchez, "Competition Versus Optimal Control in Groundwater Pumping," Water Resources Research, v. 16, n. 4, Aug. 1980. In general, a first order differential equation of y + Py = Q has a solution of Y(t) = Q/P + (Yo - Q/P)exp-Pt, where exp-Pt designates the number e raised to the -Pt power. When the power of the exponent is positive, the time path Y(t) moves away from the value Q/P, and when the power of the exponent is negative, the time path Y(t) approaches Q/P.

height and exponentially approaches the steady state, with the rate of the approach governed by the value of the exponent. If the steady state height is above the initial height (as in the case of a serverly overdrafted basin) then the height of the water table will approach the steady state from below, and If the steady state height is below the initial height (as when mining of the groundwater is optimal), then the time path will approach the steady state from above.

Replacing H in W = d + ckH with the time path for the height of the water table H(t), gives the time path for the rate of groundwater use under common property access to the basin:

$$W(t) = d + ck\left(\frac{R - ad}{ack} + \left[H_0 - \frac{R - ad}{ack}\right] e^{-\frac{ack}{AS}t}\right)$$

$$= \frac{R}{a} + \left[ckH_0 - \frac{R}{a} + d\right] e^{-\frac{ack}{AS}t} \qquad (10)$$

Again, this time path for the extraction rate has a steady state value, R/a, and the time path goes from an initial rate of use to the steady state rate of use as determined by the term in the brackets and by the exponent. Notice that the higher the value of H_0 the larger the value of W(t). It is the height of the water table relative to the surface elevation that determines the profitability of groundwater use, so the higher the water table, the cheaper it is to pump any given acre-foot of water, and the more water will be pumped. At the initial time t=0, W=d+ckH becomes Wo=d+ckHo. Replacing d+ckHo in the above equation with Wo, it is easy to see that the equation W(t) also describes a time path from an initial state (W(t=0) = Wo) to a steady state (W(t= infinity) = Wss).

The above time paths for the height of the water table H(t) and for the rate of extraction W(t) will be called the common property equations, $H_{cp}(t)$ and $W_{cp}(t)$ respectively, because they were derived from the myopic economic decision rule. They will be compared to the optimal control equations which will be the present discounted value maximizing height of the water table and rate of extraction, $H_{oc}(t)$ and $W_{oc}(t)$ respectively. After this comparison, the two sets of two equations will be used to determine the income from the different rates of groundwater extraction.

III. B. Optimal Control Equations

The optimal control values for H(t) and W(t) are found by maximizing the present value of groundwater use subject to the physical constraint imposed by the basin's dynamic behavior. Groundwater use not only increases the present net income, but also imposes future costs on groundwater users by increasing the depth to groundwater. The net present value of income from groundwater use is a measure of income earned from the use of the groundwater resource. Owners of such a resource will desire to use the resource in such a way as to maximize the income earned from the resource. As explained before, however, the property rights institutions determine the way in which the resource can be used and thus the income that is derived from that use.

Graphically, income earned in each time period can be shown as the area below the value of the marginal product curve (VMP) and above the marginal cost curve (MC) as in Figure 4-1. Over time in an overdrafted basin, the marginal cost curve will rise if the depth to groundwater increases. Income in each successive period will be less as the marginal cost curve rises. The total, over all time periods, of the future incomes discounted to the present is the net present value of income earned from the use of the resource. The rate of groundwater extraction governs the rate at which MC rises and the time at which the steady state is reached. Maximizing the discounted present value of future income requires determining a time path of extraction, which is called the optimal control rate of extraction.

(Associated with this optimal time path of extraction is an optimal time path for the height of the water table.)

Mathematically, the optimal control time path for extraction and the optimal control time path for the height of the water table is found by maximizing over time the difference between total willingness to pay for use of the resource and total cost of using the resource, subject to the physical availability of the resource. Integrating the value of marginal product curve, $P = g/k - (1/k)W$, to obtain the total willingness to pay for the groundwater to its users during any single time period:

$$\int_0^W P\, dw = \frac{g}{k}W - \frac{1}{2k}W^2 \tag{11}$$

and subtracting from this the total cost of groundwater extraction

$$TC = (f - cH)W \tag{12}$$

gives a one-period income (INC) from extracting W acre-feet of groundwater from a water table H feet high:

$$INC = \frac{g}{k}W - \frac{g}{2k}W^2 - (f - cH)W. \tag{13}$$

Discounting each period's income to the present and adding them together will give the rent earned by the users of the groundwater. Differences in W and H under common property and optimal control will produce the differences in the discounted present value of income.

To obtain the optimal control groundwater extraction rate and height of the water table, the mathematical procedure calls for the maximization over a given time horizon of an objective function subject to resource availability constraints. The economic objective is to maximize the net social value over all time periods from use of the resource, or the rent that can be derived from its use.[30] The objective function is

$$\max \int_0^T e^{-rt} \left[\frac{g}{k}W - \frac{1}{2k}W^2 - (f - cH)W \right] dt \tag{14}$$

which is maximized subject to the physical limit of the available groundwater given by

$$\dot{H} = \frac{R - aW}{AS}$$

The technique for maximizing a time dependent objective function subject to a time dependent restriction requires combining them into an equation called the Hamiltonian[31]

$$V = e^{-rt}\left[\frac{g}{k}W - \frac{1}{2k}W^2 - (f - cH)W\right] + \lambda\left(\frac{R - aW}{AS}\right). \tag{15}$$

The necessary condition for an interior maximum are[32]

$$e^{-rt}\left(\frac{g}{k} - \frac{1}{k}W - f + cH\right) = \frac{a}{AS}\lambda$$

$$\dot{\lambda} = -e^{-rt}cW$$

$$\dot{H} = \frac{R - aW}{AS}$$

and the transversality condition requires that

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30 See Chapter 5, Charles W. Howe, Natural Resource Economics - Issues, Analysis, and Policy, New York: John Wiley and Sons, 1979.

31 See Anthony C. Fisher, Resource and Environmental Economics, Cambridge: Cambridge University Press, 1981, p. 81-82; and Gordon R. Munro and Anthony D. Scott, "The Economics of Fisheries Management," in Handbook of Natural Resource and Energy Economics, Volume II, edited by Allen V. Kneese and James L. Sweeney, Amsterdam: Elsevier-North Holland, 1985, pp 638-640. The Hamiltonian measures the net economic effect of extraction as the difference between the current benefits minus future costs in each time period.

32 The first necessary condition says that to maximize the Hamiltonian, extract groundwater at such that the net benefit from the last unit extracted (at any time t) is equal to the cost caused by the loss of the unit from the stock of groundwater. The second necessary condition says that the rate of change in the value of a unit of groundwater left in the ground is equal to the present discounted value of the dividend earned from avoinding extraction. The dividend in this case is the avoided cost of extraction (a negative contribution to the Hamiltonian), and so it has a negative value. The third necessary condition is a restatement of the physical constraint.

$$\lambda(t) \Rightarrow 0 \quad \text{as } t \Rightarrow \infty$$

where

$$\lambda(t) = \frac{AS}{a} e^{-rt}[\frac{g}{k} - \frac{1}{k} W(t) - f + cH(t)] . \tag{16}$$

l is interpreted as the value of a unit of groundwater in terms of the objective function, or the value of a unit of groundwater in the basin. l(t) gives the time path of the value of groundwater left unextracted.

Following the solution procedure used in Gisser and Sanchez[33] which requires the use of the transversality condition, the optimal control results are

$$H(t) = R(\frac{1}{ack} + \frac{1}{rAS}) - \frac{d}{ck} + [H_0 - R(\frac{1}{ack} + \frac{1}{rAS}) + \frac{d}{ck}]e^{-\frac{ack}{AS}t} \tag{17}$$

$$W(t) = \frac{R}{a} + [kcH_0 - \frac{R}{a} + d - \frac{kc}{rAS}R]e^{-\frac{ack}{AS}t} \tag{18}$$

As solutions to differential equations, these equations have the general purpose of describing a time path of the height of the water table and of the rate of groundwater extraction from an initial condition (Ho and d+ckHo respectively) to the steady state ([R/ack]+[R/rAS] and R/a respectively). The time paths approach the steady state exponentially.

IV. Comparing the Results

Gathering the equations for the common property and the optimal control time path of the height of the water table together

[33] Micha Gisser and David A. Sanchez, "Competition Versus Optimal Control in Groundwater Pumping," Water Resources Research 16, 4, (Aug. 1980), p. 640. The transversality condition is a constraint on the model which prevents the net benefit from marginal increases in H from growing without bound. Such a condition is necessary if the quantity of the resource is unlimited. Since there is no limit in this model placed upon either the bottom of the aquifer or the volume of water in the basin (restrictions which if available would likewise produce a termination time for the model), the transversality condition is used.

$$H_{cp}(t) = \frac{R - ad}{ack} + [H_0 - \frac{R - ad}{ack}] e^{-\frac{ack}{AS}t} \tag{8}$$

$$H_{oc}(t) = R(\frac{1}{ack} + \frac{1}{rAS}) - \frac{d}{ck} + [H_0 - R(\frac{1}{ack} + \frac{1}{rAS}) + \frac{d}{ck}] e^{-\frac{ack}{AS}t} \tag{17}$$

the difference is that the optimal control steady state has an "extra" term of R/rAS. This is a positive number meaning the steady state height of the water table will be greater under optimal control than under common property.[34] Naturally, how much greater is inversely related to the rate of interest, because groundwater is a capital asset. Under common property rights users of the aquifer have no guarantee that water they leave in the ground (water that increases the height of the aquifer) will be theirs to capture tomorrow, hence the effective rate of interest is infinity, and R/rAS is zero in the common property equation. Because R/rAS is the present value to the water user of an increase in the height of the water table, the common property height of the water table is lower than the optimal control height of the water table in each time period.

The optimal control height of the water table and the amount of water left in the ground (by a single owner or by multiple owners acting to maximize the present value of the groundwater) will be less the higher the interest rate. At a high interest rate the users would choose to liquidate their capital (i.e. groundwater stock) now and invest the money at the high

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[34] The height of the water table is greater under optimal control even though R/rAS enters the optimal control equation (17) twice. The steady state height of the water table under optimal control is greater than under common property by an amount equal to R/rAS. But also, this same difference affects the adjustment from the present height, H_0, to the steady state, by an amount equal to $-(R/rAS)(e^{-ackt/AS})$. However, since $e^{-ackt/AS}$ is less than one, the positive addition to the optimal control height (i.e. R/rAS) is greater than the negative addition (i.e. $-(R/rAS)(e^{-ackt/AS})$). Also, the negative component goes to zero as t increases.

interest rate. In other words, the users of the groundwater will pump more at a high interest rate, leaving less water in the ground, and a lower water table will result.

Similarly, juxtaposing the common property and the optimal control groundwater use time paths

$$W_{cp}(t) = \frac{R}{a} + \left(ckH_0 - \frac{R}{a} + d\right) e^{-\frac{ack}{AS}t} \tag{10}$$

$$W_{oc}(t) = \frac{R}{a} + \left(ckH_0 - \frac{R}{a} + d - \frac{ck}{rAS}R\right) e^{-\frac{ack}{AS}t} \tag{18}$$

the difference depends upon ckR/rAS, which is found only in the optimal control equation. The two use rates will coincide under any one of the following conditions:

a) k is small (zero): a perfectly inelastic demand will mean $k=0$, which is to say that if there is a fixed water requirement, then groundwater use will be constant over time under both common property and optimal control;

b) c is small (zero): if the marginal costs of extracting groundwater from deeper depths is zero, then there is no externality from common property use of the groundwater;

c) r is large (infinity): same as the discussion regarding r in $H(t)$;

d) AS is large: this argument, used by Gisser and Sanchez, says that if the basin is infinitely large, then extraction will have no affect upon the height of the water table, on the depth to groundwater, or on the present discounted value of income.

Employing the above time paths for the height of the water table under both common property, $H_{cp}(t)$, and optimal control, $H_{oc}(t)$; and the time paths for the rate of groundwater extraction under both common property, $W_{cp}(t)$, and optimal control, $W_{oc}(t)$, we can determine the discounted present value of income from groundwater use under both institutional structures, called the $RENT_{cp}$ and the $RENT_{oc}$, as follows:

$$RENT_{cp} = \int_0^t e^{-rt}[\frac{g}{k} W_{cp} - \frac{1}{2k} W_{cp}^2 - (f - cH_{cp}) W_{cp}]$$

$$RENT_{oc} = \int_0^t e^{-rt}[\frac{g}{k} W_{oc} - \frac{1}{2k} W_{oc}^2 - (f - cH_{oc}) W_{oc}] \, .$$

These equations will be used below to determine the economic incentive to change property rights from a common property structure to an optimal control structure. The difference between the values of these equations, or RENToc-RENTcp, is a measure of the incentive groundwater users have to adjudicate groundwater rights.

V. Data Sources and Model Results

Data for the variables in this model came from published and unpublished reports by the San Joaquin District of the California Department of Water Resources. The Department of Water Resources (DWR) has developed a four-part simulation model of the San Joaquin Valley's water use, water availability, agricultural output, and groundwater hydrology. The DWR has divided the Valley into 33 detailed analysis units (DAUs) based upon major canal and river boundaries and major water agency boundaries (see Figure 4-2 and Table 4-1). Covering the Valley's 8.5 million acres, the DAUs range in si2e from 43,000 acres to 635,000 acres. A complete set of data fitting the model used in this chapter was available for 23 of the 33 DAUs, the missing data being from the DAUs on the west side of the valley. The data for these western DAUs are incomplete because these DAUs overlie lands that are inconsistent with the use of the storativity coefficient "S" and the consumptive use percentage "a" — a problem created by the Corcoran Clay which prohibits replenishment of groundwater by return flow to the confined aquifer from which groundwater is pumped in these DAUs.35 Data for the 23 DAUs used in this model can be found in an Appendix at the end of the chapter. 36

The present discounted value under optimal control was calculated using an interest rate of 4 percent and an interest rate of 10 percent over a 40-year time horizon, and the present discounted value under common property was calculated using a 4 percent rate of interest and a 40 year time horizon.37 A discount rate is the interest rate used to discount future incomes to the present, and is determined by the opportunity cost of foregone present

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35 The general conclusion that present levels of groundwater use under common property exceed those of optimal control has additional consequences on the western side of the Valley. Water that seeps below the surface creates a perched water table that is separated from the major body of groundwater by a nonporous layer of clay. Excessive rates of groundwater use create an excessively high perched water table. This water is contaminated with salts and pesticides which not only cause agricultural damage, but damage to wildlife in the northwestern portion of the Valley. An additional benefit of optimal control over common property rates of groundwater use, though not measured in this model, Is the decrease In crop and wildlife damage from the perched water table.

36 Sources for particular datum are:
R -- Table 3-7, p. 3-46, California Department of Water Resources, "Final Report The Hydrologic-Economic Model of the San Joaquin Valley", Appendix C, prepared by Jay E. Noel and Dennis McLaughlin, in San Joaquin Valley Hydrologic-Economic Modeling Study, Bulletin 214, Sacramento: Department of Water Resources, Dec. 1982.
g/kand 1/k --Table 2, p. 21 .MaranguMarete, "San Joaquin Valley Hydrologic-Economic Model," in Economics and Groundwater, edited by Donald Finlayson, New York: American Society of Civil Engineers, 1984.
a,A,S, and C -- Table 5, p. 18, California Department of Water Resources, San Joaquin District, "A Method for Estimating the Value of Surface Water in Conjunctive Use Areas," Memorandum Report prepared by W. Max Hubbart and Lawrence P. Owens, March 1985.1 would like to thank Terry Erlewine of the California Department of Water Resources, San Joaquin District for providing me with this and other information.
H_0 -- Appendix, California Department of Water Resources, "Hydrologic Data," San Joaquin District Report, June 1981.

37 The use of two interest rates has two benefits: first it tests the model's sensitivity to the interest rate, and second, since the goal of the model is to measure incentive for adjudication of groundwater rights, it accounts for possible differences in time perception of different groups of individuals. Adjudication of groundwater rights will likely place restrictions on the use of groundwater which will lower crop production and farm income in the short run, but because future water table heights will be increased, future farm income will be higher. The higher the discount rate, the less these future increases in income contribute to the incentive to adjudicated groundwater rights.

income.[38] The DWR has used 4 percent as its rate of discount because, as said in Appendix C to Bulletin 214, "Four percent is approximately what the long-run real interest rate has been over the past 20 years and was felt that it was an adequate measure of the social discount rate."39 Ten percent is assumed to be an adequate approximation of the private discount rate, or private opportunity cost of foregone present income, which includes adjustments for inflation, risk, etc. It is expected that the benefits from efficient groundwater management will be less under the 10 percent discount rate than for the 4 percent discount rate because the net benefits from optimal control accrue further in the future (and are thus heavily discounted) compared to the net benefits from common property use of groundwater

In Table 4-2 are the results of the model for the 23 DAUs for which there is a complete set of data. For each DAU is listed (1) the net present discounted value under optimal control at a *4%* discount rate for a 40-year time horizon (OPTIMAL CONTROL AT *4%)* , (2) the net present discounted value under optimal control at a *10%* discount rate for a 40-year time horizon (OPTIMAL CONTROL AT 108), (3) the net present discounted value under common property at a *4%* discount rate for a 40-year time horizon (COMMON PROPERTY AT *4%),* and (4) the difference between optimal control and common property at the *4%* discount rate for a 40-year time horizon -- which measures the incentive to institute groundwater rights adjudication as a means of establishing groundwater management -- (RENT FROM OPTIMAL CONTROL AT *4%).*

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38 For a discussion of the many issues surrounding discount rates, see R. Lind, editor, Discounting for Time and Risk in Energy Policy. Baltimore: Johns Hopkins Press, 1982. The willingness to trade-off income between the present and the future may differ between society and the individual because their opportunities for investing present income may differ. The present discounted value of income varies inversely with the discount rate, hence the economic incentive to change institutions may be greater from the point of view of society (i.e. the state) than from that of the individual i.e. irrigators in the Valley) if society has a lower discount rate.

39 California Department of Water Resources, Appendix C, Bulletin 214, prepared by Jay Noel and Dennis McLaughlin, p. 52.

Of the 23 DAUs evaluated in this model, 21 DAUs showed a positive economic incentive to switch from common property to optimal control at a 4 percent discount rate over both time horizons (see Table 4-2 "Results of the Model" and Figure 4-3 "Graphic Representation of the Incentive to Adopt Optimal Control"), In the aggregate-, the present discounted value from maintaining common property use of groundwater at a 4 percent discount rate over a 40 year time horizon is $3.09 billion. The present discounted value of groundwater use under optimal control is $4.38 billion, The economic incentive, in terms of increased groundwater rent, to change the institutional structure of groundwater use is $ 1.29 billion dollars. For the water years 1971-1976, during which the DWR's average simulated overdraft was 1.04 million acre-feet per year, 1.44 million acre-feet of overdraft was accounted for by the 23 DAUs in this study.[40] The $ 1.29 billion incentive to change the Institutional structure from common property rights to private rights is the economic benefit from eliminating this overdraft.

The two DAUs which do not show a positive economic incentive are DAU 236 and DAU 240. For DAU 236 the time horizon is too short for the benefits of optimal control to surpass the present discounted value of groundwater use under common property. When the time horizon was stretched from 40 years to 50 years, the greater becomes the optimal control benefits compared to common property, and, given sufficient time, the former will surpass the latter. The model is run only for a finite period of time, and the discounted values of groundwater use, which are produced by the model, are a function of that time period. Note that under optimal control, the present discounted value of groundwater use is negative at a 10 percent discount rate for DAU 233 and at both a 4 percent and a 10 percent discount rate for

[40] The 10 other DAUs had a net 31 million acre-feet of "surplus groundwater" because of the inclusion of areas in the northeastern portion of the Valley where groundwater inflows are particularly volumous, and because delivery of State Water Project water to the west side of the Valley resulted in a temporary elimination of overdraft in this area.

DAU 236; but these results become positive and continue to grow as the time horizon is stretched beyond 40 years. 41 Nevertheless, this may be too long of a time horizon for farmers in these DAUs to support efficient groundwater management policies.

As for DAU 240, the negative value for the rent from optimal control at a 4 percent discount rate is negative for a different reason. The current height of the groundwater table is above the steady state height of the groundwater table (i.e. the area's aquifer is not overdrafted), so no benefits whatsoever are realized from optimal control, and common property exploitation is the preferred institution. Over the given time horizons and the present rates of groundwater use, the height of the groundwater table remains above its steady state level, and so overdraft of the aquifer may continue without adverse economic consequences.

The economic benefits of optimal control at a 10 percent discount rate are less than optimal control at a 4 percent discount rate (i.e. the social discount rate). If individual decision-makers value their use of groundwater under both common property rights and the adoption of optimal control (i.e. calculate the "rent from optimal control") at a 10 percent discount rate (i.e. where 10% represents an alternative rate of return on capital investment in private markets, which may differ from the social rate of return), then 12 of the 23 DAUs

[41] The optimal control model forces the height of the water table to its steady state height. As a result, overdrafted basins have present water use rates reduced (even below the steady state rate of use) until the water table reaches its steady state height. Though present day use is curtailed under optimal control, future use rates will be greater than under common property rights. Common property use of groundwater may be higher than under optimal control early in time, but later in time optimal control rates are greater. If the value of early common property use is large compared to the value of later optimal control use, it will take a long time horizon before the discounted sums of optimal control use can outweigh the initial benefits of early common property use.

do not show an economic incentive to adopt efficient groundwater management.[42] and the Valley as a whole would not have an incentive to eliminate common property rights to groundwater.[43]

The results of the model, at a 4 percent discount rate, show that there is a strong economic incentive to change institutional structures exists in the San Joaquin Valley, but that, as seen in Figure 4-3, the incentive is spatially concentrated in the southern portion of the Valley where overdraft is prevalent, and is not strong in the east-central part of the Valley. Highly negatively correlated with this economic incentive are the conditions under which surface water is delivered. Institutions providing delivery of large volumes of cheap

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42 These DAUs are numbers 213,215, 233, 234,235,236, 239, and 240 in the eastern portion of the Valley, and numbers 255, 256, 258, and 261 in the southern portion. The one overriding characteristic of these districts is the large number of canals delivering surface water. In addition to the Friant-Kern Canal in the eastern DAU's, these DAU's have numerous privately built canals delivering cheap surface water. The southern DAU's have access to surface water from the Kern River, the Friant-Kern Canal, the Cross Valley Canal, and the California Aqueduct. The first three of these provide relatively inexpensive surface water. For all of these DAU's except 255, the variable cost of an acre foot of groundwater is more expensive than an acre foot of water from surface sources (see Tables 7 and 9 in California Department of Water Resources, "Final Report, The Hydrologic-Economic Model of the San Joaquin Valley", Bulletin 214, Sacramento, Ca., Dec. 1982, p. 37 and p. 44).

Two of these DAU's (233 and 258) are particularly sensitive to the change in discount rate from 4 percent to 10 percent. Because the positive net benefits from optimal control accure in future periods and the positive net benefits of common property accure relatively more in the present, a 10 percent discount rate requires a long time horizon before optimal control's net benefits will outwiegh common property. A large discount rate means that groundwater users give a large relative weight to the present. More so for DAU's 233 and 258 than for the other DAU's, the delay in net benefits caused by optimal control will cause a decrease in rent that accures to groundwater users when their discount rate is 10 percent AND a 40-year time horizon is used to calculate the present discounted value.

43 Aside from the change in the discount rate, a reason the 12 DAU's have a reduced incentive to adopt efficient groundwater management is the inelasticity of demand. Particularly in the DAU's south of the city of Fresno, the large capital investment in grapes greatly reduces the elasticity of demand for water in this region. As for the other DAU's closer to the city of Bakersfield, the explanation may be that the increased surface water provided by the Cross Valley Canal and the Arvin-Edison Canal likewise have greatly reduced reliance upon groundwater and reduced the incentive to efficiently manage it.

surface water are prevalent in the eastern portion of the Valley, but are lacking in south.[44] With a lack of abundant and cheap surface water comes a greater dependence upon groundwater to sustain the economic life of the agricultural communities. This greater dependence means that the externality associated with common property rights is greater, and-so too is the benefit from its elimination.

Though, as implied above, the communities in the San Joaquin Valley would receive increased income by changing the institutional structure of groundwater use, they have not been motivated to bring about the change. The institution of common property has retained control over groundwater extraction over such a large area of the state despite economic incentive to change it because of the transactions costs and other barriers associated with

[44] Those DAU's in the southern section of the Valley who have switched their water source from the Cross Valley Canal to the Friant-Kern Canal are the ones who lose the incentive to adopt efficient management at a 10% discount rate. The water districts in these DAU's were not only able to secure for themselves a more stable source of (Class I) water, but the water was at subsidized prices. Otherwise, the southern DAU's are without access to reliable water storage projects. Instead, these areas benefit from Army Corps of Engineer projects regulate stream flow and which allow the large landholders to avoid acreage restrictions of the U. S. Bureau of Reclamation.

eliminating the institution of common property.[45] These barriers are of two types: dollar costs and institutional constraints. The dollar cost of adjudicating (as a means of changing the institutional structure) groundwater rights in the San Joaquin Valley will be estimated below. The institutional constraints -- which include the inertia of the present institutions, the distribution of the economic benefits from and of the costs of changing institutions, and the politics of surface water alternatives available to the Valley -- will be analyzed in the following two chapters.

45 One alternative institutional solution is to import more surface water into the Valley. If sufficient surface water is imported to eliminate the condition of overdraft, one main consequence of adjudication is accomplished. According to the San Joaquin Valley Agricultural Committee (ibid., p. 67):

> ...SWRCB (the State Water Resources Control Board) is empowered to seek judicial action through the Attorney General to limit ground water extractions through adjudication. Without an adequate supply of supplemental water, elimination of overdraft in the southern San Joaquin Valley, under this procedure, would require removal of about 600,000 acres of land from irrigated agricultural production.
>
> The economy of California and of the region would be severely impacted by such an occurrence. The 600,000 acres amounts to about six percent of the irrigated land in California and about 18 percent of that in the southern San Joaquin Valley. It is estimated that the value of the direct loss would be about $530 million annually.

If importing additional surface water is an exclusive alternative to adjudication, then the foregone $530 million annually from the elimination of 600,000 acres from production should be counted as a cost of an adjudication (if indeed the response of irrigators to a restriction of groundwater production to the safe-yield of the basin is the elimination of 600,000 acres from production). The policy option of importing surface water in amounts equal to the overdraft avoids the problem of displaced agricultural production. If 1.4 million acre-feet of water were imported into the Valley at a cost of $ 132 per acre-foot (annualized cost of yield from enlargement of Shasta Dam by 1.4 million acr8-feet) then the cost of eliminating overdraft would be $ 185 million dollars annually. If we count the $530 million as a benefit from not adjudicating groundwater, and subtract from this benefit the $ 185 million of acquiring imported surface water, then the elimination of overdraft has an annual net value of $345 million. A $345 million annual net benefit discounted at 4 percent has a net present value of $8,625 billion. Hence, the importation of additional surface water may be a more profitable institutional change to undertake than the adjudication of groundwater rights.

VI. Groundwater Adjudication Costs

This section will first digress to the adjudication costs of the basins on the South Coastal Plain before it addresses the issue of the costs for the San Joaquin Valley. This is done to add some perspective to the benefits and costs of groundwater adjudication. The measure of the dollar cost of an adjudication is only the first approximation to the full cost of changing groundwater institutions, because these costs generally include only the amounts paid to engineers, lawyers, economists, and other professionals and do not include the lost time and effort nor any real dollar costs incurred before the adjudication. Among the costs that are not counted towards the cost of adjudication is the lost output due to the uncertainty of tenure of groundwater use which exists both before and during the adjudication. The dollar costs of adjudication include the expense of conducting hydrologic studies of the basin, of retaining legal services during the sometimes long adjudication process, and of negotiating and maintaining working agreements among the parties to a law suit. It is assumed the benefits gained from adjudicating groundwater rights exceed these costs; otherwise well informed individuals would not have undertaken and continued the actions necessary to complete the adjudication.

Groundwater rights adjudication is not new to the state of California, as shown in the previous chapter. Experience has shown that adjudication can be expensive in terms of time as well as money -- the Raymond Basin adjudication took 12 years to complete and the West Basin adjudications dragged on for 19 years. One of the main reasons why the Orange County Water District initiated its taxing program was because of the length of these adjudications. Benefitting from the experience of the West Basin, the Central Basin groundwater users negotiated a settlement <u>before</u> turning to the courts, and the result was a suit that was decided in three years and nine months. In turn, the groundwater users in the Main San Gabriel Basin and the Chino Basin followed the example of the Central Basin resulting in substantial savings in time and costs.

The total cost of concluding an adjudication is strongly related to the time of the adjudication process, because the longer the case takes to conclude, the longer the legal services must be retained. The development of groundwater management in the Central Basin was a watershed case in the South Coastal Plain because rather than being initiated by adversarial proceedings, the adjudication began with a negotiated agreement among the groundwater users (which assigned property rights to the safe-yield of the basin as the means for managing the basin).[46] The development of a pre-trial management plan substitutes the costs of negotiation for the costs of legal services by shortening the time of the adjudication process.

Because it provides inflexible guidelines along which property rights to groundwater are established, the mutual prescription doctrine assists the negotiation process. Water rights are based only upon past use, so the allocation of rights is generally a technical question, leaving the participants to the negotiation very little room for argument. In keeping with the 1928 amendment to the California Constitution calling for all water of the state to be put to reasonable and beneficial use.[47] the decision of Los Anoeles v. San Fernando determined that claims based on means other than adverse possession would not necessarily preclude the court from granting private property rights to the groundwater[48] if those means granted rights for reasonable and beneficial uses. Determining rights by measuring reasonable and beneficial uses rather than continuous use over a five-year period will make negotiations

46 Another reason the time and dollar costs of the Central Basin adjudication were so low was that the negotiated agreement was based on hydrologic studies by the plaintiffs, the West and Central Basin Replenishment District, rather than on a more time consuming study by the state's DWR as was the case in the Raymond Basin and West Basin adjudications.

47 Article 3 Section 10, California Constitution.

48 City of Los Angeles v. Citv of San Fernando. 123C. 1 (1975).

more difficult. Because of the increased possibility of hold-outs and because mutual prescription cannot be applied to water owned by public entities, the rules for allocating groundwater may become more flexible and the cost of this flexibility Is Increased time and money costs of negotiation. But, on the contrary, the Chino Basin negotiations were completed after Los Angeles v. San Fernando and the court case was decided in just three years and twenty-five days.

Only the cost of legal services is unique to an adjudication of rights. As in the case of the Orange County Water District, groundwater management can be accomplished by means other than adjudication. Nevertheless, hydrologic studies of the Orange County Basin were necessary, as were the expense of organizing the district and procuring from the legislature the powers to tax groundwater users. But it must be emphasized that there are costs other than the out-of-pocket or accounting costs when developing a groundwater management plan. Other economic costs include the unpaid time and effort of all parties involved in developing a management plan for a basin. The time and efforts of civic leaders who first realized the need for a management plan, the efforts of the small farmer who attends a water users' association meeting so he can get his point of view across to others, and the work of the "public entrepreneur" who builds a bandwagon of support for the management plan are not counted in the out-of-pocket costs of the adjudications, but they are real costs nonetheless.

Albert Lipson's "Efficient Water Use in California: The Evolution of Groundwater Management in Southern California" estimates some of the costs of adjudication groundwater rights on the South Coastal Plain.[49] A summary of this data is provided in Table 4-3. For

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[49] Albert J. Lioson. Efficient Water Use in California: The Evolution of Groundwater Management in Southern California. Rand Corporation, Santa Monica, Ca., 1978, pp. 5 and 6. The cost estimates In each case are given for the plaintiff, and where appropriate, it is assumed the legal costs of the defendants in the case are the same. To this cost is added the cost of engineering studies to arrive at the estimated adjudication costs. The costs of initiating, continuing, and completing a management plan outside of the courtroom is not included in these costs, and may be the most substantial of the costs involved in managing a groundwater basin.

each of the basins the following information is given: the number of parties involved In the law suit, the amount of safe-yield to which prescriptive rights were granted, and the legal and/or engineering costs of the adjudication for both parties involved in the law suit. Unfortunately there are a number of gaps In the cost data, In particular the legal costs are unavailable for the West Basin.50 Also, some basins had additional costs to developing their management plans which are not Included In Figure 4-2, such as the Central Basin's purchase of 98,000 acre-feet of replenishment water[51] over the three years of the suit which allowed the amount of negotiated rights to exceed the safe yield of the basin. Including these considerations the adjudication costs per acre-foot of adjudicated rights are: Raymond Basin $ 10 AF, West Basin $9 AF, Central Basin $6.80, Main San Gabriel $6 AF, and Chino Basin $6 AF. Again, these costs do not include the cost of negotiating agreements that were in existence before the court case began.

Turning to the San Joaquin Valley, the Department of Water Resources has estimated the cost of San Joaquin Valley groundwater adjudication.[52] The whole of the San Joaquin Valley is

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[50] One of the attorneys to the West Coast Basin adjudication, Rex Goodcell, Jr., estimated that five million dollars had been spent by the parties to the case "...because of legal questions having to do with basin boundaries, the formulae for the quantitative determination of water rights and procedural road blocks...". If not an overstatement, then the cost per acre-foot of adjudicated groundwater rights in the West Coast Basin is over $76. The annual wholesale value of the water supplied from the groundwater reservoir has been estimated at $ 1.2 million, which capitalized at an annual percentage rate of ten percent is worth $ 12 million dollars. If the adjudication process prevented destruction of the basin, then the benefits from the adjudication ($12 million) outweigh these costs ($5 million).

To obtain an estimate of the West Coast Basin's legal fees, we can look at the legal fees of the Raymond basin which preceded it and of the Central Basin which followed it. Legal fees to the plaintiff in the Raymond Basin were $100,000. The $225,000 legal and engineering costs in the Central Basin can be arbitrarily assigned as $200,000 legal costs and $25,000 engineering costs, the latter figure being so small because the hydrology of the basin was already well studied by the plaintiff, the West and Central Basin Replenishment District, which began replenishment operation before the case began. Taking the midpoint of these estimates gives us $ 150,000 as the legal costs to the plaintiffs in the West Coast Basin suit. Therefore total adjudication costs in the West Coast Basin are estimated to be $600,000.

[51] Elinor Ostrom, p. 508. At $ 10 per acre-foot, the total cost of this water was $980,000.

52 See Appendix A, California Department of Water Resources, The Hydrolooic-Economic Model of the San Joaquin Valley. Bulletin 214, December 1982, pp. 145-157.

assumed to be subject to the adjudication, but this Is not necessarily the way adjudication will proceed. As was the case along the San Gabriel River and the Santa Ana River, one section of the Valley may decide to adjudicate rights In its area (i.e. the Kern County Water Agency or the Fresno Irrigation District), and If successful In meeting the needs of water users, the adjudication process may proceed to surrounding sub-basins of the Valley until all or most of the Valley is adjudicated. A piece-wise adjudication of the basin may be less expensive since the homogeneity of the parties to the suit may facilitate negotiation of a settlement. As was the case on the South Coastal Basin, once one area of a hydrologically interconnected system adopts an income-enhancing management plan, the other areas of the system Jump on the bandwagon, or to mix metaphors, fall into place like dominoes.

The gain from changing groundwater institutions has been shown above to vary considerably across the Valley. In some DAUs there is little to be gained from adopting controls over groundwater extraction, whereas in others the economic incentive is very strong. These differences in rents are due to differences in the marginal value of groundwater as well as differences in the marginal extraction cost. These differences, in turn, are due to the availability of surface water and the types of crops grown (which affect the marginal value of groundwater), and due to the depth to groundwater and to the type of physical formation in which the water is found (which affect the marginal extraction cost). Physical differences underlie the economic differences and the economic differences are part of the incentive to change institutions. Though the following treats the adjudication of the San Joaquin Valley as if it were a whole, it must be remembered that the adjudication could be as diverse and complex as is the Valley itself.

The following costs have been identified as part of the adjudication process in the San Joaquin Valley.[53]

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[53] p149-155, ibid.

1). naming and serving of 20,000 agricultural defendants plus 10,000 others - $5 million.

2). development of technical information - $48,215 million.

3). trial costs - $32,552 million.

According to the Department of Water Resources, "This is a conservative estimate. With incidental costs such as travel and postage, the total costs for pretrial technical investigations and the trial itself could easily exceed $85 million."[54] with a physical solution, the amount of groundwater pumping will be limited so as to eliminate overdraft, which is a problem In specific locations of the Valley. Though the safe-yield is 7.5 million acre-feet per year, it is concentrated in the northern and eastern portions of the Valley. If an exchange pool were not created so that areas which put the highest value on an acre-foot of water could purchase water from those areas which have a lower value per acre-foot, then a safe yield solution could cause great economic losses in particular locations of the Valley.

In comparison to the South Coastal Plain figures above, if all 7.5 million acre-feet of safe-yield from the Valley's groundwater basin are adjudicated, the cost per acre-foot of adjudicated right would be $ 11.34. This is more than any previous adjudication and nearly twice as much as in the Chino Basin, the most recent of the South Coast Basin's adjudications. Given a gross benefit of adjudication of $ 1.29 billion and a cost of adjudication of $85 million, the net benefit from adjudicating groundwater rights in the San Joaquin Valley is $ 1.205 billion dollars at a 4 percent discount rate.

VII. Conclusion

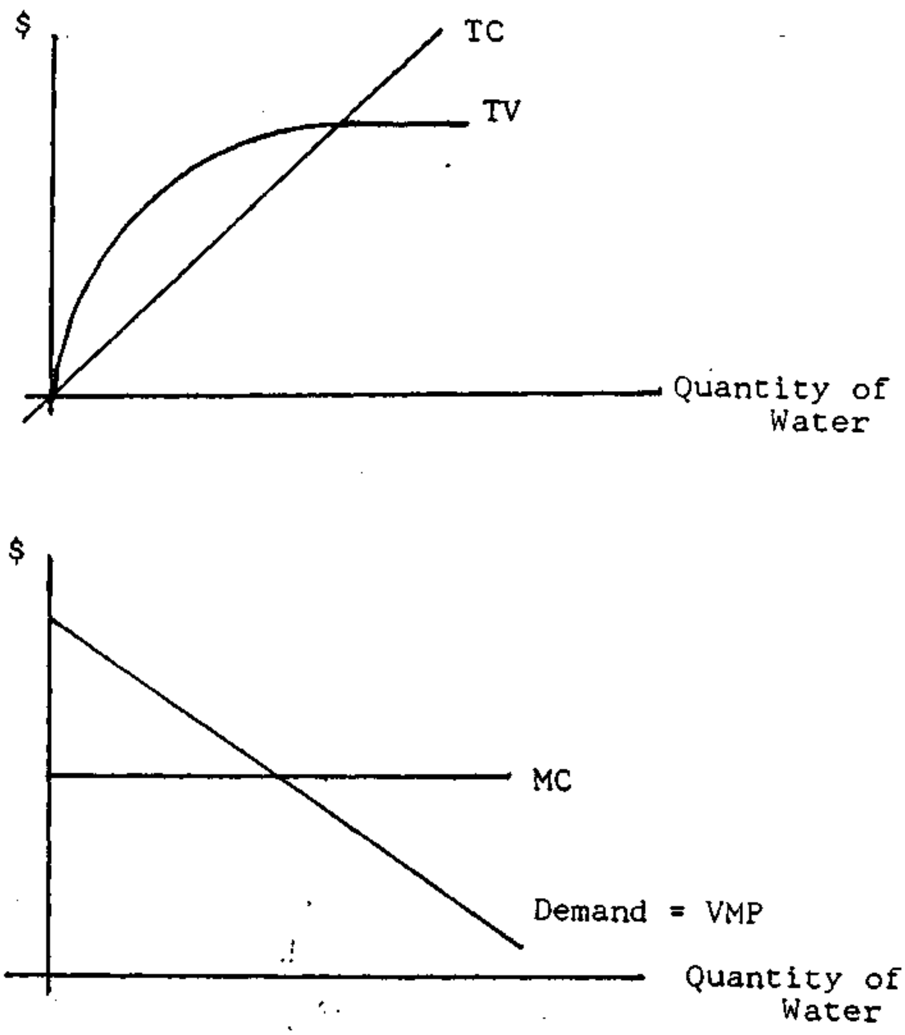
The net present value from groundwater use under optimal control is greater than the net present value from groundwater use under common property. The difference between the

[54] p. 155, ibid.

two is claimed to be an economic incentive to adjudicate groundwater rights in the San Joaquin Valley, This incentive, net of adjudication costs, is $ 1.205 at a 4 percent discount rate.

Figure 4-1

Total and Marginal Curves for Water Use



TV Total Value
TC Total Cost
VMP Value of Marginal Product
MC Marginal Cost

Table 4-1

Detailed Analysis Units and
Major Water Agencies
in the San Joaquin Valley

Detailed Analysis Unit	Name	Major Water Agencies
206	Modesto-Oakdale	Modesto ID, Oakdale ID
207	Warnersville	--
208	Turlock	Turlock ID, Stevinson WD (part)
209	Montpelier	Ballico-Cortez WD, Merced ID (part)
210	Merced	Merced ID (part)
211	Fahrens Creek	--
212	El Nido-Stevinson	Stevinson WD (part), El Nido ID, La Branza WD
213	Madera-Chowchilla	Madera ID, Chowchilla WD
214	Berenda Creek	--
215	Gravelly Ford	Gravelly Ford WD, Sierra WD, Columbia Canal Company
216	Delta-Mendota	Central California ID, West Stanislaus ID, Patterson WD
233	Fresno	Fresno ID
234	Academy	--
235	Raisin	Raisin City WD
236	Consolidated	Consolidated ID
237	Lower Kings River	Laguna ID, James ID, Riverdale ID
238	Hanford-Lemoore	Kings County WD, Lemoore Canal Company
239	Alta	Alta ID
240	Orange Cove	Orange Cove ID
241	Tulare Lake	Tulare Lake Basin WSD, Corcoran ID
242	Kaweah Delta	Kaweah Delta WCD, Tulare ID, Lindmore ID
243	Tule Delta	Lower Tule River ID, Pixley ID, Delano-Earlimart ID
244	Westlands	Westlands WD
245	Kettleman Plain	Pleasant Valley WD, Devil's Den WD
246	South Tulare Lake	Dudley Ridge WD, Hacienda WD
254	Kern Delta	Kern Delta WD, Rosedale-Rio Bravo WSD
255	Semitropic	Semitropic WSD, Buena Vista WSD
256	North Kern	North Kern WSD, South San Joaquin MUD, Shafter-Wasco ID
257	Kern Uplands	Kern-Tulare WD
258	Arvin-Wheeler Ridge East	Arvin-Edison WSD, Wheeler Ridge-Maricopa WSD
259	Antelope Plain	Belridge WSD, Berrenda Mesa WD, Lost Hills WD
260	Buena Vista Valley	West Kern WD
261	Arvin-Wheeler Ridge West	Wheeler Ridge-Maricopa WSD

ID - Irrigation District
MUD - Municipal Utility District
WCD - Water Conservation District
WD - Water District
WSD - Water Storage District

Source: Calif. Dept. of Water Resources, Bulletin 214

Table 4-2
Results of the Model

DAU	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 10%	[illegible]	[illegible]	[illegible]
COMMON PROPERTY	[illegible]	[illegible]	[illegible]
RENT FROM OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
DAU	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 10%	[illegible]	[illegible]	[illegible]
COMMON PROPERTY	[illegible]	[illegible]	[illegible]
RENT FROM OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
DAU	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 10%	[illegible]	[illegible]	[illegible]
COMMON PROPERTY	[illegible]	[illegible]	[illegible]
RENT FROM OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
DAU	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 10%	[illegible]	[illegible]	[illegible]
COMMON PROPERTY	[illegible]	[illegible]	[illegible]
RENT FROM OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
DAU	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 10%	[illegible]	[illegible]	[illegible]
COMMON PROPERTY	[illegible]	[illegible]	[illegible]
RENT FROM OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
DAU	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 10%	[illegible]	[illegible]	[illegible]
COMMON PROPERTY	[illegible]	[illegible]	[illegible]
RENT FROM OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
DAU	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 10%	[illegible]	[illegible]	[illegible]
COMMON PROPERTY	[illegible]	[illegible]	[illegible]
RENT FROM OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
DAU	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]
OPTIMAL CONTROL AT 10%	[illegible]	[illegible]	[illegible]
COMMON PROPERTY	[illegible]	[illegible]	[illegible]
RENT FROM OPTIMAL CONTROL AT 4%	[illegible]	[illegible]	[illegible]

Table 4-3

Number of Water Rights, Safe Yield, and Legal Costs for Adjudicated Basins on the South Coastal Plain

Basin	Number	Safe-Yield	Legal Costs
Raymond	31	21,840 AF	$300,000
West	491	65,500 AF	$307,000
Central	>700	272,000 AF	$225,000
Main San Gabriel	190	200,000 AF	$750,000 to $1 million
Chino	1300	145,000 AF	$750,000 to $850,000

Source: Albert J. Lipson, "Efficient Water Use In California: The Evolution of Groundwater Management in Southern California" Santa Monica: Rand, 1978.

Appendix

Detail Analytical Unit (DAU)	209	210	211
Size of Aquifer in square feet	2516000	4414000	
Empty Storage Capacity	917000	291000	
Area (A)	80000	155000	27700
Storativity (S)	0.1	0.104	0.09
Depth to Groundwater in feet (d)	129	57	100
Elevation of Land Surface	239.3	158.8	300.8
Height of Groundwater Table (Ho)	110.3	101.8	200.8
Marginal Cost of Extraction (c)	0.23	0.31	0.26
Area times Storativity (AS)	8000	16120	2493
Return Flow in acre-feet	42084	57876	23400
Total Recharge to aquifer (R)	106800	127400	56000
Natural Recharge	64716	69524	32600
Intercept of Demand Function (g/k)	47.868	17.625	52.998
Slope of Demand Function (k)	3116.24	9699.32	1270.02
Return Flow Coefficient (a)	0.64	0.58	0.61
Initial Groundwater Usage (Wo)	116900	137800	60000
Steady State Groundwater Use (Wss)	101118.75	119868.97	53442.623

Detail Analytical Unit (DAU)	235	236	237
Size of Aquifer in square feet	5049000	7224000	4843000
Empty Storage Capacity	2325000	860000	2216000
Area (A)	185000	175000	180000
Storativity (S)	0.139	0.161	0.139
Depth to Groundwater in feet (d)	134	68	152
Elevation of Land Surface	200.4	300.1	209.4
Height of Groundwater Table (Ho)	66.4	232.1	57.4
Marginal Cost of Extraction (c)	0.16	0.3	0.21
Area times Storativity (AS)	25715	28175	25020
Return Flow in acre-feet	211302	125664	129796
Total Recharge to aquifer (R)	454600	244200	276400
Natural Recharge	243298	118536	146604
Intercept of Demand Function (g/k)	101	47.237	54.825
Slope of Demand Function (k)	6101.26	2238.14	7898.89
Return Flow Coefficient (a)	0.61	0.58	0.53
Initial Groundwater Usage (Wo)	541800	299200	350800
Steady State Groundwater Use (Wss)	398849.18	204372.41	232704.76

Detail Analytical Unit (DAU)	212	213	214
Size of Aquifer in square feet	5404000	4134000	3130000
Empty Storage Capacity	569000	1553000	1682000
Area (A)	217000	178000	73900
Storativity (S)	0.094	0.101	0.094
Depth to Groundwater in feet (d)	108	113	159
Elevation of Land Surface	135.5	219.7	331.9
Height of Groundwater Table (Ho)	27.5	106.7	172.9
Marginal Cost of Extraction (c)	0.2	0.25	0.21
Area times Storativity (AS)	20398	17978	6947
Return Flow in acre-feet	176464	156156	54649
Total Recharge to aquifer (R)	381800	336100	117200
Natural Recharge	205336	179944	62551
Intercept of Demand Function (g/k)	32.845	47.748	94.999
Slope of Demand Function (k)	16911.89	4401.41	2344.12
Return Flow Coefficient (a)	0.59	0.58	0.63
Initial Groundwater Usage (Wo)	430400	371800	147700
Steady State Groundwater Use (Wss)	348027.12	310248.28	99287.302

Detail Analytical Unit (DAU)	215	233	234
Size of Aquifer in square feet	4374000	7958000	718000
Empty Storage Capacity	868000	1719000	141000
Area (A)	161000	265000	26200
Storativity (S)	0.115	0.127	0.112
Depth to Groundwater in feet (d)	112	77	86
Elevation of Land Surface	167.1	293.7	452
Height of Groundwater Table (Ho)	55.1	216.7	366
Marginal Cost of Extraction (c)	0.16	0.26	0.3
Area times Storativity (AS)	18515	33655	2934
Return Flow in acre-feet	168880	127176	10004
Total Recharge to aquifer (R)	328400	255500	22100
Natural Recharge	159520	128324	12096
Intercept of Demand Function (g/k)	90.938	31.605	69.962
Slope of Demand Function (k)	3610.11	5373.46	515.84
Return Flow Coefficient (a)	0.6	0.58	0.59
Initial Groundwater Usage (Wo)	422200	302800	24400
Steady State Groundwater Use (Wss)	265866.67	221248.28	20501.695

Detail Analytical Unit (DAU)	238	239	240
Size of Aquifer in square feet	4280000	3280000	273000
Empty Storage Capacity	912000	472000	142000
Area (A)	168000	133000	38200
Storativity (S)	0.119	0.099	0.089
Depth to Groundwater in feet (d)	85	60	55
Elevation of Land Surface	226.7	327.6	441.1
Height of Groundwater Table (Ho)	141.7	267.6	386.1
Marginal Cost of Extraction (c)	0.28	0.27	0.32
Area times Storativity (AS)	19992	13167	3400
Return Flow in acre-feet	127072	103960	13702
Total Recharge to aquifer (R)	301100	219900	45100
Natural Recharge	174028	115940	31398
Intercept of Demand Function (g/k)	85.461	116.45	533.6
Slope of Demand Function (k)	5349.02	1797.59	114.93
Return Flow Coefficient (a)	0.62	0.6	0.66
Initial Groundwater Usage (Wo)	334400	259900	40300
Steady State Groundwater Use (Wss)	280690.32	193233.33	47572.727

Detail Analytical Unit (DAU)	242	243	254
Size of Aquifer in square feet	10185000	8222000	8081000
Empty Storage Capacity	2274000	4082000	4687000
Area (A)	450000	425000	340000
Storativity (S)	0.107	0.097	0.133
Depth to Groundwater in feet (d)	109	181	195
Elevation of Land Surface	324	326.7	360.5
Height of Groundwater Table (Ho)	215	145.7	165.5
Marginal Cost of Extraction (c)	0.3	0.25	0.21
Area times Storativity (AS)	48150	41225	45220
Return Flow in acre-feet	304066	244264	237429
Total Recharge to aquifer (R)	721400	539100	494400
Natural Recharge	417334	294836	256971
Intercept of Demand Function (g/k)	60.933	76.525	76.641
Slope of Demand Function (k)	11219.57	11104.94	86595.08
Return Flow Coefficient (a)	0.63	0.62	0.63
Initial Groundwater Usage (Wo)	821800	642800	641700
Steady State Groundwater Use (Wss)	662434.92	475541.94	407690.48

Detail Analytical Unit (DAU)	255	256	257
Size of Aquifer in square feet	6603000	2333000	406000
Empty Storage Capacity	2331000	4354000	1573000
Area (A)	272000	235000	69000
Storativity (S)	0.115	0.1	0.087
Depth to Groundwater in feet (d)	265	309	504
Elevation of Land Surface	258.4	374.8	609.1
Height of Groundwater Table (Ho)	-6.6	65.8	105.1
Marginal Cost of Extraction (c)	0.2	0.22	0.19
Area times Storativity (AS)	31280	23500	6003
Return Flow in acre-feet	162260	116208	12736
Total Recharge to aquifer (R)	358200	246500	40000
Natural Recharge	195940	130292	27264
Intercept of Demand Function (g/k)	80.801	111.15	403.06
Slope of Demand Function (k)	6570.3	5458.52	1722.95
Return Flow Coefficient (a)	0.65	0.64	0.68
Initial Groundwater Usage (Wo)	463600	322800	39800
Steady State Groundwater Use (Wss)	301446.15	203561.25	40094.118

Detail Analytical Unit (DAU)	258	261
Size of Aquifer in square feet	607000	1297000
Empty Storage Capacity	4839000	2639000
Area (A)	182000	159000
Storativity (S)	0.143	0.108
Depth to Groundwater in feet (d)	375	290
Elevation of Land Surface	697.6	740.4
Height of Groundwater Table (Ho)	322.6	450.4
Marginal Cost of Extraction (c)	0.23	0.23
Area times Storativity (AS)	26026	17172
Return Flow in acre-feet	63342	30060
Total Recharge to aquifer (R)	194500	50300
Natural Recharge	131158	20240
Intercept of Demand Function (g/k)	88.659	66.681
Slope of Demand Function (k)	4060.09	4065.04
Return Flow Coefficient (a)	0.66	0.7
Initial Groundwater Usage (Wo)	186300	100200
Steady State Groundwater Use (Wss)	198724.24	28914.286

CHAPTER FIVE

ALLOCATION AND PRICING OF SURFACE WATER IN THE SAN JOAQUIN VALLEY AND THEIR EFFECT ON GROUNDWATER USE

I. The Interconnection Between Surface Water and Groundwater

The substantial groundwater resources of the San Joaquin Valley were not tapped until late in the nineteenth century, when pumps first became available. Initially, groundwater extraction was constrained by pumping technology, but as technology advanced, more areas were brought into production. Not until the 1930's, after the advent of increasingly sophisticated pumps and well-drilling technology, and after rapid expansion in the number of irrigated acres, had serious overdraft problem developed in the San Joaquin Valley.[1] The response by groundwater users to the Valley's first overdraft problem was an effort to increase surface supplies. Thus began the modern pattern of irrigated agriculture in the San Joaquin Valley -- recurring cycles of groundwater depletion halted through the importation of supplemental surface supplies, followed by a short recovery in the groundwater table, but then a resumption of groundwater depletion. In general, the problems of water scarcity and groundwater overdraft have been ameliorated by the development of additional supplies, and little or no attention has been given to the possibilities of regulating demand.

The use and management of surface water is influenced by the cost of groundwater. As groundwater resources became depleted or overdrafted, it became profitable for the farmers

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[1] California Department of Public Works, Divisions of Engineering and Irrigation and of Water Rights, Ground Water Resources of the Southern San Joaquin Valley. Bulletin No. 11, by S.T. Harding, Sacramento: California State Printing Office, 1927. Harding reported that of the 1,370,000 acres irrigated in the area, 800,000 acres secured all or part of their water supply by pumping from wells, and about 180,000 acres of this overlied groundwater basins subject to overdraft conditions. See pp. 7-9.

to pool their financial resources so that surface water supplies can be augmented by the construction of storage reservoirs and distribution facilities. The first major storage facilities, all located in the north and east portion of the Valley and built by local, public water districts, were the Tullock Reservoir on the Stanislaus River, the Don Pedro Reservoir on the Tuolumne River, and Lake McClure behind Exchequer Dam on the Merced River. As overdraft threatened the livelihood of farmers down the eastern side of the Valley and in the southern half of the Valley which Is called the Tulare Lake Basin, the farmers appealed to the federal government for help. The federal government's Army Corps of Engineers and the Bureau of Reclamation responded by building surface water storage dams in the Valley, and by importing additional surface water from northern California. Likewise, long-standing overdraft problems in the western portion of the San Joaquin Valley led the farmers now served by the Westland Water District to petition the federal government for the construction of the San Luis unit of the Central Valley Project. The farmers now served by the Kern County Water Agency petitioned the state government for the construction of the State Water Project to alleviate the expense of pumping groundwater from great depths.[2]

Though the high water costs associated with groundwater overdraft have been considered the motivating force behind the Central Valley Project and the State Water Project,[3] little

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[2] Though the Westlands's farmers were almost singlehandedly able to convince the federal government to provide them with surface supplies, the construction of the State Water Project, though It greatly benefited the farmers of the San Joaquin Valley, would not have been possible without the political and financial support of the Los Angeles metropolitan area.

[3] S.T. Harding. Water in California. Palo Alto: N-P Publications, 1960, p. 24; Erwin Cooper. Anueriuct Emnira. Gtanriale: The Arthur H. Clark Co., 1968, p. 148-49; Joe S. Bain, Richard E. Caves, and Julius Margolis, Northern California's Water Industry. Baltimore: The Johns Hopkins Press for Resources for the Future, Inc., 1966,p, 298-300; San Joaquin Valley Agricultural Water Committee. Water Resources Management in the Southern San Joaquin Valley California. Glendale: Bookman-Edmonston Engineering, Inc., 1979, p. 1; Barbara T. Andrews and Sally K. Fairfax, "Groundwater and Intergovernmental Relations in the Southern San Joaquin Valley of California: What are All these Cooks Doing to the Broth?", University of Colorado Law Review 55, 2, (Wtr. 1984), p. 150-151.

effort has yet been made by the farmers of the San Joaquin Valley to control or regulate their use of groundwater. In most efforts at controlling overdraft, such as the Kern Water Bank, the State Water Project (or some similar collective organization) will deliver water to groundwater users who will In turn reduce their pumpage.[4] But these programs augment surface supply without reducing demand, and they do not eliminate the common property rights to groundwater which are the cause of groundwater overdraft.

Water districts are the collective organizations by which farmers secure access to surface water. Water districts have a motive to secure water In such a quantity and at such a cost as will permit its constituents, as a group, to maximize their profits from the productive use of that water. In their study of the northern California water industry, Bain, Caves, and Margolis explain the behavior of water districts as if they were "users' cooperatives".[5] As users' cooperatives, water districts develop water supplies solely for their members. However, because water is scarce, Valley farmers, through their representative water districts, must compete for it. Competition for this scarce resource necessitates some means of allocation. The nature and consequence of the competition among the user's cooperatives is explained by Bain as follows: "Typically, the competition for scarce natural water supplies is not a rivalry for day-to-day or year-to-year supplies but for long-term or perpetual legal rights to continuing stream flows and the water yield of underground aquifers. The result of

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4 California Department of Water Resources, California Water: Looking to the Future, Bulletin 160-87, Sacramento: California Department of Water Resources, 1987, p. 48. In the Kern Water Bank, the SWP delivers surplus water but is credited with groundwater in storage for its deliveries of surface water to groundwater pumpers which adds to its dependable supply. This project is expected to increase the firm yield of the SWP by 140,000 acre-feet. For a more detailed study of the exchange of surface water for groundwater programs in the San Joaquin Valley see San Joaquin Valley Agricultural Water Committee, Water Resources Management in the Southern San Joaquin Valley California. Glendale: Bookman-Edmonston Engineering, Inc., 1979.

5 Joe S. Bain. Richard E. Caves, and Julius Marqolis. Northern California's Water Industry, Baltimore; The Johns Hopkins Press for Resources for the Future, Inc., 1966, p, 9.

such competition is to establish rigid and inflexible allocations of water rights among different users, which once established are effectively perpetual at law."[6]

Rigidity is perhaps the most important characteristic of the San Joaquin Valley's water supply system. Rigidity exists in the physical, economic, and Institutional factors of the water supply environment of the San Joaquin Valley. Physical aspects of the Valley's water supply system underscore this rigidity. Despite the engineer's ability to store and transport water between seasons and between basins by the use of dams and canals, once the capital facilities for a given distributional pattern of water is established, that pattern is permanently fixed. Streambeds and dams and canals cannot be relocated to serve alternating portions of the valley as can a water hose on a backyard lawn.

The lifespan of the capital resources required to store and transport water is an obvious physical factor characterizing the rigidity of surface water allocation in the Valley, but moreover it gives rise to an economic factor of rigidity. The expense of massive capital structures requires economic institutions that encourage water users to undertake long-term capital investments. Water district financing of water supply projects involved the sale of long-term bonds, bonds backed by the assessed value of district lands. Security of tenure in property rights to water, and other water law rigidities which tie property rights in land to property rights in water, helped encourage the sale of these bonds by minimizing uncertainty as to the assessed value of district lands.

In conjunction with the long time horizons which characterize the physical and economic aspects of the water supply landscape, the rigid and inflexible allocations of water in the San Joaquin Valley is punctuated by the permanence with which water rights are established under the riparian and appropriation doctrines. Rigidities found in surface water allocations, such as the riparian doctrine's restriction of water use to only that land which borders the water

[6] Ibid, p. 10.

source, inhibit water transfers between water districts or individuals. Water rights gained under the riparian doctrine lock water use to particular locations and specific parcels of land, thus blocking the movement of water to its highest and best use, The cumbersome and expensive legal procedure for making a definitive determination of water rights under the appropriation doctrine, likewise discourages transfers of water to those most willing to pay for it Such surface water rigidities which lock water into its present use, also encouraged the importation of surface water as a solution to an area's overdraft problems. Rising groundwater costs, faced by individuals who are unable to purchase water applied in less productive uses, served as a motivation for organized efforts to import additional surface water, yet the importation has not solved the problems caused by groundwater overdraft.

Though the hydrological interconnection between surface water and groundwater has long been recognized, the economic and institutional connections between surface and ground waters are often overlooked. As will be shown later, rigidity in surface water laws (an institutional variable) contributed to the incidence of groundwater overdraft and to high costs for groundwater extraction (an economic variable). It will also be shown that the ways in which water prices are set not only determine the amount of surface water that is used but also the amount of groundwater that is pumped. Groundwater is not priced, nor its use regulated, by the same water districts that deliver and price surface water supplies to farmers. The quantity of groundwater pumped is determined by individual farmers who price groundwater according to its extraction cost. The inability to control both surface water and groundwater usage, because of the lack of a coordinated water pricing system, is one reason why groundwater overdraft problems persist.

Efficient groundwater management is a conservation policy. Conservation in the context of groundwater resources emphasizes achieving economic efficiency by pricing water at its marginal value in a market that provides for transfers of water to its highest uses.[7] Conservation of groundwater requires a change in the property rights to groundwater before a market can allocate groundwater efficiency. A groundwater conservation policy cannot be achieved in isolation from surface water conditions. Referring to conservation policy, Dean Mann warns that "(s)uch a policy must have a sound technical foundation, such as recognizing the interrelationship between surface and groundwater... it must have a clear economic foundation in recognition of the financial and economic incentives that motivate farmers and irrigation district managers; it must have a clear political foundation in the broader water management policy system."[8]

Realizing the many faceted connection between surface water and groundwater, the achievement of groundwater conservation requires that surface water allocation constraints be recognized. Surface water allocation constrains the establishment of efficient management of groundwater in the San Joaquin Valley because of the diversity and variety of circumstances under which water is used in the valley. Most studies of the San Joaquin Valley's groundwater use problems have assumed the Valley to be an agriculturally homogeneous whole; or have concentrated on the similarities of the water supply situation in certain regions of basins of the Valley. Below I will emphasize that the opposite is true -- the valley is made up of diverse and different regions. These ~~varieties~~ in physical, economic and institutional

[7] For an explanation of different types of conservation, see Dean Mann, "Institutional Framework for Agricultural Water Conservation and Reallocation in the West: A Policy Analysis," in Water and Agriculture in the Western U.S., edited by Gary, D. Weatherford, Boulder: Westview Press, 1982, p. 12-13. For applications of conservation policy oriented to achieve economic efficiency, see Richard E. Howitt, Dean E. Mann and H.J. Vaux, Jr., "The Economics of Water Allocation," in Competition for California Water, edited by Earnest A. Engelbert, Berkeley: University of California Press, 1982, pp. 136-182:B. Delworth Gardner, "Water Pricing and Rent Seeking in California Agriculture," in Scarce Water and Institutional Change, edited by Kenneth D. Frederick, Washington, D.C.: Resources for the Future, Inc., 1986, pp. 67-101.

[8] Dean Mann, ibid., p. 11.

components of the Valley's surface water supply system Impede the establishment of efficient groundwater management by increasing the transactions costs of establishing such management. Among the many water districts in the Valley, a wide variation exists in terms of their groundwater overdraft problems because of differences in surface water availability and in surface water prices. The greater the variations, the less likely an agreement can be reached on managing groundwater.

This chapter is a story of the economic and institutional characteristics of the existing pattern of surface water allocation in the San Joaquin Valley and how these surface water characteristics affect not only the quantity and location of groundwater overdraft, but also the prospect for a solution to the problem. The rigidity of the surface water allocation pattern and the variations in surface water and groundwater conditions prevent the realization of a more efficient means of groundwater management than presently exist in the San Joaquin Valley. In the preceding chapter it was discovered that the establishment of an efficient management plan will increase the net present value of groundwater use by almost one billion dollars over the present common property form of management. However, before this economic benefit from groundwater management can be realized, there are physical, economic and institutional problems associated with surface water management that must be solved. Overcoming these problems represent transactions costs to the instituting of efficient groundwater management.

II. Surface Water Augmentation as a Policy Response to Groundwater Overdraft Problems

II. A. Introduction

Water has always been a valuable commodity in the San Joaquin Valley, but the form of the competition for the water resources of the Valley has changed continuously over the past century. The earliest battles over water (and water rights) were between ranchers who had established riparian rights to the rivers of the valley, and the land developers and farmers who set out to irrigate the eastern portion of the valley by use of water rights under the appropriation doctrine.[9] Though the riparian right was a means of securing rights to the natural flow of a stream or river, the appropriation doctrine, in conjunction with legislative enactments such as the Wright Act of 1889, was a means of securing rights to spring and summer flows which were enlarged due to snowmelt runoff. The end to the legal competition for seasonal flows between riparians and appropriators was signaled by the 1928 Amendment to the California Constitution which subjected all water use to the appropriation doctrine's criterion of highest and best use, though it recognized existing water rights gained through the riparian doctrine.[10]

Following the 1928 Amendment, continually increasing demands for water led to a new era of competition for water in the Valley. As these seasonal flows became fully appropriated during the 1920's,[11] as the expense of storage and distribution facilities became too great for the resources of the Valley's farmers, and as the groundwater resources of the Valley became seriously overdrafted; the state and federal governments came to provide the means by which water could be transferred across major basins from northern California to the San Joaquin Valley. Unlike during the early decades of irrigated agriculture, local water districts were no longer the main participants in the capture, storage and distribution of water in the Valley but

[9] See comments on the Lux v. Haggin case decided on Jan 4, 1888 in Edwin Cooper, Aqueduct Empire, Glendale: Arthur H. Clark, Co. 1968, pp. 40-2. The decision in this case is credited with motivating the Wright Act which was passed by the legislature the following year.

[10] Article XIV, Section 3 of the California Constitution. The amendment States, "It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the water or unreasonable use (thereof) be prevented, and that the conservation of such water is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare." The amendment does not remove the riparian doctrine from the state, but a system of water rights, called the California Doctrine, has evolved which allows the two doctrines to co-exist. Vested property interests of riparian water rights are still protected as long as the water gained by that right is put to reasonable and beneficial use.

[11] S. T. Harding, Water in California, Palo Alto: N-P Publications, 1960, p. 24.

were reduced to retail agencies which purchased water from large wholesalers such as the U.S. Bureau of Reclamation and the California Department of Water Resources. Nevertheless, the surface water allocation patterns and pricing policies developed by the laws which established the local water districts have had profound effect on the groundwater condition in the San Joaquin Valley.

The pattern of development of surface water supplies varies across different regions of the San Joaquin Valley, and so does the condition of groundwater overdraft vary throughout the Valley. Three regions of surface water allocation as they affect groundwater overdraft can be recognized in the San Joaquin Valley.[12] The first is in the northern and eastern portion of the Valley, which developed its water allocaion characteristics in the pre-1928 period. Most surface water developments which took place in this region were on a local scale motivated by the formation of the early public water districts. The second is the region served by the Central Valley Project by which the federal government became involved in California's water supply system. The third region is the far western portion of the Valley which introduced the state government (i.e. the Department of Water Resources) into the water supply situation in the San Joaquin Valley. I do not Intend to repeat nor rewrite the history of surface water

[12] These phases follow very closely those developed by Andrews and Fairfax, ibid, who discuss the following four phases in the historical development of surface water and groundwater institutions in California: A) Phase One, 1850 to 1900-Surface Water as a Privately Controlled Resource; B) Phase Two, 1900 to 1920-The Onset of Groundwater Pumping and State Control of Surface Water; C) Phase Three, 1920 to 1960-Federal Surface Water Domination and the Development of Local Groundwater Programs Outside the Southern San Joaquin, and D) Phase Four, 1960 to the Present-The Environmental Era and Federal-State Conflicts Over Surface Water. With respect to groundwater use they say, on p. 160, that:

"The development of the Valley's present groundwater management scheme can be divided into four phases. Initially, there was local development of surface water with little, if any, groundwater pumping. The second phase saw increased state control over the allocation of surface water and the advent of the exploitation of groundwater. During the third phase, the federal government rose to prominence as a major supplier of surface water to the Valley. Most recently, in the fourth phase, the statewide commitment of "full water development" in the State is being challenged, both directly by increasingly effective environmental advocates, and indirectly by fiscal concerns and governmental budgetary constraints."

developments in the state, but to emphasize how the past surface water developments influence today's groundwater overdraft and the prospects for instituting efficient groundwater management.

Groundwater overdraft, manifesting itself as a high cost of groundwater, is claimed to have been the impetus for both the Central Valley Project and the State Water Project.[13] But in contrast, the early development of surface water, first by those with riparian rights and later by local water districts, took place without groundwater over-draft, because before the advent and widespread use of the deep-well turbine pump, the relatively primitive technology of groundwater pumping limited the amounts of groundwater extraction to below the amount of recharge. But the development and widespread use of the turbine pump on groundwater wells in the 1920's and a huge expansion in the number of wells in use in the San Joaquin Valley, caused sufficient amounts of groundwater to be extracted so that farmers began feeling the pinch of higher water costs. The sting of reduced profits caused the farmers to back the Central Valley Project, first as a state project and later as a federal one.[14] The pinch of high groundwater costs affected irrigators differently, and the Bureau of Reclamation distributed its water not to those whose profits were pinched the tightest, and thus would benefit the most from its water, but to those who squealed the loudest.[15]

The relationship between surface water use and groundwater use underwent substantial change with the advent of the large storage projects such as the Central Valley Project and the

[13] See sources in supra footnote 3.

[14] See Cooper, p. 149, for a discussion of how the Central Valley Project first began as a state project and eventually became a federal project.

[15] Bain, Caves and Margolis, ibid, p. 594, say "At a more fundamental level, one can wonder about areas of irrigable land, still unirrigated or served only from limited ground-water sources, which might have provided alternative services areas for supplies imported from the Sacramento River to the San Joaquin Valley....The point is that no serious study of this or other possibilities seems to have been made: the orientation of the Bureau's efforts in designing the Central Valley Project was toward responding to demand voiced with considerable political force."

State Water Project. Before the Great Depression, storage projects were undertaken only by local water districts.[16] These projects were spurred not so much by an imbalance between groundwater and surface water costs as by the expansion of irrigated agriculture supported by the development of public irrigation districts and by the use of the appropriation doctrine. Nevertheless, these local and small scale developments had profound affects upon groundwater conditions in the Valley and upon the large scale surface water projects that followed. The following sections of this chapter will explore the differences between the local small-scale surface water developments and the federal and state large-scale surface water projects to determine how these differences affect groundwater use and overdraft, and to explain how these differences constrain the achievement of efficient groundwater management. From a political perspective, nonhomogeneity among groundwater users in the San Joaquin Valley prevents coagulation of coalitions in favor of groundwater management. Instead of groundwater management, political forces have pushed for increased surface water imports.

The following sections of the chapter look at surface water development by three distinct institutions: local water districts, the federal government, and the state of California. Local water districts have primarily been responsible for allocating the waters of the Merced, Tuolumne, Stanislaus, Kings, and Kaweah Rivers. The federal government's Central Valley Project allocates water throughout the Valley through the Friant-Kern Canal, the Delta-Mendota Canal, and the Madera Canal. The state of California's California Aqueduct delivers water to farmers on the west side of the Valley. The intent of these sections Is to point out not only the rigidity with which water is allocated, but that the differences and varieties in the

[16] From Tables 33 and 34, Bain, Caves, and Margolis, p. 582; of the 1.56 million acre-feet of reservoir capacity in large dams built before 1921 in Northern California, private water companies accounted for 614,000 acre-feet of the storage whereas public irrigation districts accounted for only 47,000 acre-feet. However, of the 3.6 million acre-feet of storage capacity behind large dams built between 1921 and 1931, 83,880 acre-feet was accounted for by public irrigation districts while private irrigation districts built no large storage dams.

water supply situation of farmers across the San Joaquin Valley adds to the transactions costs of efficiently managing the groundwater resources of the Valley. Finally, the chapter concludes with an analysis of the water pricing policies of the local water districts, of the federal Bureau of Reclamation, and of the state Department of Water Resources -- again pointing out that differences in these water pricing policies is a contributing factor to the lack of efficient groundwater management in the San Joaquin Valley.

II. B. Surface Water Development by Local Water Districts In the San Joaquin Valley

II. B. 1. Early Irrigation Development

The few rivers flowing through the valley, see Figure 5-1, made competition for their water very concentrated, local, and Intense. The major rivers of the San Joaquin Valley flow from out of the Sierra Nevada Mountains which form the eastern border of the Valley. Most of the water carried In the rivers Is runoff from the snow melting high in the mountains. The great rivers, swollen by the melted snow, flow westerly across nearly two-thirds of the valley, before they reach the trough of the valley floor. From the depths of the Valley the waters in the northern rivers (the Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, and the San Joaquin) enter the San Joaquin River and are transported north to the Delta; whereas the water in the southern rivers of valley (the Kings, Kaweah.Tule and Kern), enter either the Tulare Lake, the Buena Vista Lake, or disappear underground.

At the time of California's statehood, the San Joaquin Valley's meager water supply made the land unsuitable for little more than ranching, Droughts of the early 1860's nearly ruined the cattle Industry which was succeeded by wheat farming as the dominant income earning activity in the Central Valley. The extension of the railroad into the San Joaquin Valley in the 1870's and the spread of private irrigation enterprises (made possible by the release of labor and capital resources from the declining mining industry) greatly diversified the Valley's agricultural base, as well as intensifying water demands. This intensification in water demands eventually led to conflict over water and water rights.

Irrigation in the Valley began on the lands closest to the river bottoms. Riparian rights were the primary means of obtaining access to irrigation water, and the shallow depths of the early wells could reach only that groundwater which was bolstered by the seepage from the river bottom. But because the acres of land away from the river's edge were more fertile and more numerous, farmers began a long and arduous fight to change the rules that governed surface water allocation.[17] Because of the primitive technology in groundwater pumping, irrigators relied upon surface water supplies. Few major groundwater problems existed during this phase in the San Joaquin Valley's development, though this period contained the 1903 decision of Katz v, Walkinshaw which formally changed, for the whole state of California, the laws under which use of groundwater were determined.

As of the turn of the century, groundwater was not a constraint to agricultural development in the San Joaquin Valley -- the amount of groundwater extracted was quite modest in comparison to the high levels of groundwater replenishment. In the early periods of irrigation development, the technology for groundwater use was very primitive. In 1880 the

[17] The appropriation doctrine was the form of water law in the mining lands of the state (most of the mining lands were actually federal lands, and the federal government recognized the appropriation doctrine long before the state of California), but the state's 1850 Constitution adopted the riparian doctrine as the water law of the state. Many attempts were made in the State Supreme Court, and through the legislature, to have the state accept water rights gained by the appropriation doctrine. After a failed attempt to change the state's constitution in 1874, and after failure in the Lux v. Haggin case of 1886, the farmers turned to the state legislature. The Wright Act of 1887, the Wright-Bridgeford Act of 1897, the County Water District Act of 1913, the California Irrigation District Act of 1917, the Water Storage District Act of 1921, and many other laws were passed in the legislature to strengthened the case of appropriation rights to water as against riparian rights. Legislative support and economic dependence upon the appropriation doctrine eventually culminated in the passage in 1928 of Article 14, Section 3 which amended the California Constitution in favor of appropriation of water by requiring the application of water to its most beneficial uses. It was the strength of local irrigation districts that brought about such a profound institutional change in he state's water laws.

State Engineer reported that 188,000 acres in the San Joaquin Valley were under Irrigation,[18] but very few of these acres were irrigated with groundwater. Before the development of the deep-well turbine engine, wells would generally reach between 10 to 30 feet below the surface to draw water above ground. Even as late as 1906, there were less than 600 irrigation wells in use in the San Joaquin Valley. Groundwater extractions were about 225,000 acre-feet in 1906, approximately 700,000 in 1912, and increased to nearly 2 million acre-feet by 1930,[19] Rather than use groundwater, whose high cost would have restricted growth, surface water was the main source of moisture nuturing agricultural growth In the Valley

Development of the San Joaquin Valley's agricultural potential required the development and delivery of surface water supplies. The delivery of water was an expensive undertaking which required cooperative action by the irrigators to finance the large capital investment in the engineering, building, and maintenance of a canal system. The first irrigation enterprises were undertaken by land developers who would purchase large tracts of land, obtain rights to water, and then subdivide the land and water before selling to prospective farmers. Farmers and land developers alike soon came to realize that land without water was of no value, and that no profit could be made by operating water-delivery systems alone without the availability of nearby land to sell.

II. B. 2. Surface Water Allotments in Water Districts Along the Merced, Tuolumne, and Stanislaus Rivers

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[18] Harding, p. 80. On page 81 it is reported that the first use of a pump on a well used for irrigation in the San Joaquin Valley was in the late 1880's near Porterville.

[19] San Joaquin Valley Agricultural Water Committee, p. 20.

Rigidities and inefficiency in surface water allocation will complicate and make more expensive the instituting of efficient groundwater management. Rigidities are pervasive in the surface water allocation system that governs the San Joaquin Valley. Below are three examples, one each from different river basins of the Valley, of the types of rigidities that exist. The first example chronicles the efforts of the water districts along the Merced, Tuolumne, and Stanislaus rivers to provide irrigation water. Secondly, a brief description of the influence water allocation agreements on the Kings River had in preventing the development of needed storage projects on that river. This is followed by an example of water allocation on the Kaweah River and how surface water allocation agreements can influence groundwater use. All of these examples highlight the restrictions which private agreements among water users have on Improving the pattern of water use. Later in this chapter, focus is moved to the contributions made by both federal and state governments to the rigidities of existing water allocations.

The wider the variation in surface water allocation, groundwater use, and groundwater overdraft problems, the more difficult it will be to reach an agreement on an efficient groundwater management plan. To highlight the variation in the water supply situation of specific areas of the Valley, this section will present the surface water allocation pattern in the area of the Merced, Tuolumne, and Stanislaus Rivers (see Figure 5-2). It will show that surface water and groundwater conditions can vary even between neighboring water districts In the same river basin, and provide an example of how insular decisions by neighboring water districts lead to the provision of water by less than efficient means and create differences in surface water allocation and groundwater use between neighboring water districts.

The Merced, Tuolumne, and Stanislaus Rivers flow parallel on east-west courses before entering the San Joaquin River. The Stanislaus River (with an average yearly flow of

542,700 acre-feet) Is 12 miles north of the Tuolumne River (with an average yearly flow of 449,900 acre-feet) which in turn is 23 miles north of the Merced River (with an average yearly flow of 969,400 acre-feet). The service area of these river's five water districts is 50 miles from north to south and 20 miles from the foothills in the east to the San Joaquin River to the west. The irrigated farmlands of the water districts consist of over 480,000 acres of high-grade valley soil.

The water districts in the Stanislaus-Tuolumne-Merced river area of the valley are among the largest in the state. These districts were the only ones in the Valley wealthy enough to afford to build their own substantial water storage and distribution facilities as well as electricity generating facilities.[20] Like their federal counterparts operating the Central Valley Project, these water districts subsidize their water prices through the sale of electricity generated at their own generating facilities.[21] Other districts in the central and southern portion of the Valley have storage and diversion facilities, but not on any scale that would rival those of these districts in the north. Nevertheless, as shown below, the variation in the quantities of water allocated across these districts suggests that water is inefficiently allocated with respect to the quality of the land.[22]

Ninety-five percent of all diversions from the fierced River (the southernmost of the three rivers) is by the Merced Irrigation District which serves land almost entirely to the south of the River. Ninety percent of the Tuolumne River Is diverted by both the Turlock

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[20] The South San Joaquin Irrigation District and the Oakdale Irrigation District take their supplies from the Stanislaus River, the Modesto Irrigation District and the Turlock Irrigation District take their water from the Tuolumne River, and the Merced Irrigation District takes its water from the Merced River. These are the same rivers on which the electricity generation facilities of the districts can be found.

[21] The Oakdale and South San Joaquin irrigation districts have a generation capacity of 80,000 kilowatts on the Stanislaus River, the Turlock and Modesto irrigation districts have a 30,900 kilowatt generating capacity on the Merced River.

[22] The following analysis is based upon the discussion in Bain, Caves and Margolis, p. 619.

Irrigation District and the Modesto Irrigation District. The Turlock district serves lands entirely south of the river, diverting water to the northern edge of the Merced River; whereas the Modesto Irrigation District serves lands to the north of the Tuolumne River all the way to the southern bank of the Stanislaus River. From the Stanislaus River the South San Joaquin Irrigation District serves an area entirely north of the river, and the Oakdale Irrigation District, located to the east of the South San Joaquin and the Modesto districts, delivers water to both sides of the river. As a result of these water allocation patterns, the Oakdale, South San Joaquin, and Merced irrigation districts divert 4.8,4.7, and 4.7 acre-feet per Irrigated acre respectively, whereas the Modesto Irrigation District diverts just 4.3 acre-feet per Irrigated acre and the Turlock Irrigation District diverts only 3.3 acre-feet per irrigated acre. These acre-feet per acre amounts of delivered surface water are between fifty percent (5051) and one-hundred percent (100%) higher than for the rest of the San Joaquin Valley's irrigated lands and are so high because of the low cost of surface water provided by these districts.

This allocation of water, however, could be made more efficient in that the Turlock Irrigation District receives a smaller quota of surface water compared to the other districts -- a difference which does not appear justified in the light of the similarities in soil quality, topography, and groundwater conditions. Normally, if the productive uses to which water can be put are the same across the districts, the willingness to pay of the farmers would be approximately the same, and so should the allocation of water be the same, as well as the price charged per acre-foot. However, because the water diversions are rigidly established by California's water law, no reallocation of surface supplies is possible. And as will be shown later, the ability of the Modesto and Turlock districts to subsidize their surface water charges by generation and sale of electricity make the inefficiency of the existing allocations even worse.

II. B. 3. Surface Water Allotments In Water Districts Along the Kings River

This region, dominated by mutual water companies and public Irrigation districts, is where Irrigated agriculture first flourished. The availability of supplemental[23] surface water made possible by the storage of seasonal runoff, led to rapid development of the San Joaquin Valley's agricultural potential during the first two decades of the twentieth century. The northern and eastern portion of the San Joaquin Valley, the areas bordering the San Joaquin River, benefited the most from the development of local projects by the Irrigation districts.

The Fresno area's land-ownership pattern and water-use pattern is a result of the previously mentioned behavior of the first Irrigation enterprises. These land developers purchased the land and water rights to large tracts of land and then sold the land while attempting to hold on to the water rights and to operate water-delivery systems. Such land speculation resulted in small-acreage farms, and water provision which though it began as a private venture, was later the responsibility of public water districts. Compared to the larger water districts in the northern portion of the San Joaquin Valley, this area's historical differences in land ownership patterns and in surface water allocation had a profound effect on groundwater pumping patterns.

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[23] Surface water delivery extended from winter to early summer, a long irrigation season made possible by the run-off created by the melting of winter snows high in the Sierra Nevada Mountains. When additional water was needed before, during, or after the surface water delivery season, Irrigators made up the difference by extracting groundwater. Most groundwater was extracted during the summer to grow the second or even third crop of the year. Because groundwater was not required until after the surface water irrigation season, the groundwater reservoirs were full with water that had percolated from earlier irrigation.

A most interesting example of this land-with-water development process took place along the Kings River near Fresno.[24] As early as 1871, William S. Chapman and Moses J. Church had established the Fresno Canal and Irrigation Company. Eventual financial failure led the canal company into the hands of the Bank of Nevada in 1877, which subsequently sold it back to Church because "the bank found that there was no profit to be made from the canal alone, only from owning land as well as water." Church sold the canal company to Dr. E. B. Perrin in 1887 because of the costs of the many lawsuits against his company by riparians - who were diverting water from the Kings River. Perrin bought the downstream Laguna de Tache Ranch, which allowed him to divert the riparian waters of the ranch into his upstream canal. The Panic of 1893 brought the canal company and surrounding lands into the hands of English insurance companies from which Perrin had borrowed the money to buy the ranch. The English interests, after acquiring other canals in the area, combined them under the name of the Consolidated Canal Company. Beginning in 1895 the water delivery system in the Fresno area was owned and managed by these English capitalists, until 1921 when the properties of the canal companies were sold to the Fresno and Consolidated irrigation districts. They have remained under public management ever since.[25] The costly rigidities in water law, which required riparian owners to protect their rights in a court of law or lose them, and which prevented transfer of water separate from land, restricted irrigation development in the Valley.

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[24] Arthur Maass and Raymond L. Anderson, ... and the Desert Shall Rejoice: Conflict, Growth, and Justice in Arid Environments. Cambridge, Mass.: The MIT Press, 1978, pp. 159-175.

[25] Private canal companies acquired rights to water running in rivers either by riparian rights or, most likely, by appropriation rights. Diversion works are installed in the river and water is channeled through a principal canal to the laterals from which the farmers are served. From the laterals the water is brought to the headgates of each farm. The cost of maintenance of the canals and laterals drove most private canal companies out of existence. Private canal companies were replaced with either mutual irrigation companies which are owned and operated by the farmers, or by public irrigation districts.

This portion of the San Joaquin Valley also provided the setting for the 1886 California Supreme Court decision in Lux v. Haoqin which firmly reiterated the riparian doctrine as water law in California. The Kings River, particularly its Buena Vista Slough, became the focal point of a battle between landowners who claimed water rights under the riparian doctrine and competing landowners who claimed water rights under the appropriation doctrine. The early years of California water development, dominated by riparian rights and the fight to establish irrigation projects based upon appropriation rights, had profound affects upon the future allocation of irrigation water in the San Joaquin Valley. After the Lux v. Haggin decision in 1886, the two parties agreed to an allocation of the water of the Kings River, an allocation plan that still is in effect today.[26] Once in place, this allocation of Kings River water was sufficiently complex and rigid that it prevented the parties from beginning construction of the Pine Flat Dam in the 1920's.[27] Only after the federal government's mediation powers were brought to bear was the Pine Flat Dam completed in 1954 and the water distributed along the same grounds as proposed three decades earlier. Such rigidities and other inefficiencies in the allocation of surface water make efficient allocation of groundwater more difficult to achieve.

To highlight the connection between surface water allocation and groundwater use, using the area of the upper basin of the Kings River (see Figure 5-3), a number of comparisons will be made between lands north of the Kings River, serviced with surface water by the Fresno and Consolidated Irrigation Districts, and those lands south of the King River serviced

[26] For a detailed account of water allocation on the Kings River, see chapters five and six of Maass and Anderson, pp. 146-276.

[27] Bain, Caves, and Margol is, pp. 300 and 406. Another exam pie (from ibid., p. 318) of how existing water allocations can constrain efficiency-improving water reallocations is how the riparian Interests downstream on the San Joaquin River prevented the Madera Irrigation District from completing plans to develop a storage project above the district's lands at the present site of the Friant Dam. Delay in the construction of these surface water storage projects increased reliance upon and overdraft of groundwater.

by the Lemoore Canal and Irrigation Company, the Last Chance Water Ditch Company, and the Peoples Ditch Company.[28] In the Fresno-Consolidated area, 81 percent of Fresno farms contain less than 100 acres, whereas only 6 percent of the farms in the areas served by the three canal and ditch companies (called the Mussel Slough area) are so small. The Fresno Irrigation District serves thirty-six thousand property owners who intensively irrigate small-acreage farms. Only ninety of the properties served by the district are larger than 160 acres and they account for 13 percent of the irrigated area within the district. To serve these farms, the Fresno Irrigation District gets all of US surface water from the Kings River.[29]

Water supply In the Mussel Slough area is different than in the irrigation districts to the north because water is delivered according to the "shares" a farmer owns in the canal and ditch company. Farmers demand water when needed up to the limit of their shares. Also, they can rent their shares of water to other farmers for some agreed upon price.[30] In the Lemoore Canal and Irrigation Company there are 53 shares of stock, each representing an acre-foot of water for 640 acres of land. There are 33,920 acre-feet of water to be delivered so that 34,000 acres out of the 55,000 irrigable acres are allowed to be serviced by the company's canals. Though each owner of the various shares has a fixed and guaranteed water allotment,

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[28] The following is based on Maass and Anderson, pp. 146-274.

[29] See San Joaquin Valley Agricultural Water Committee, p. 22. Since the building of the Pine Flat Dam, the City of Fresno has a Class I water contract, and a complicated water exchange agreement with the Fresno Irrigation District, whereas the Fresno Irrigation District has a Class II contract for 75,000 acre-feet per year.

[30] This renting was done frequently in this early period of surface water development because most irrigation was accomplished by subsurface saturation. In very wet years, the water table would rise very close to the surface of the land, thus saturating the subsoil, and eliminating the need for irrigation. Those farmers overlaying water-saturated soil would rent their water to those farmers whose land did not overly such a high groundwater table. Since the water table in the area fluctuated considerably from farm to farm as well as from month to month during the irrigation season, water renting became a common practice. Today, subirrigation is not common, but water renting still occurs.

this allotment can be increased by the purchase or renting of another's share, or by varying the amount of groundwater extracted.

Before the construction of the Pine Flat Dam on the Kings River, water delivery in the Fresno Irrigation District ran from March to the end of July, but due to the construction of the dam, delivery is extended through August and the number of "runs" or deliveries increased from 10 to 12. In dry years, the district reduces the number of seasonal runs. The district delivered between 2 and 2.5 acre-feet of water in a normal year, but since the annual irrigation requirement is 4.5 acre-feet (depending on crop, irrigation system, weather, soil type, etc.), the farmers must make up the difference by groundwater pumping.[31] In a dry year, the farmers In the Consolidated Irrigation District provide three-fourths of their water needs with groundwater.

Despite the surface water supply differences between the two areas above and below the Kings River, the response to surface water scarcity in dry years is similar. Groundwater extractions are inversely related to surface water supply. To avoid crop losses during dry years, the farmers turn on their pumps earlier and run them longer. Crop production, crop values, and costs of production exclusive of water costs all remain constant during dry years. However, water costs do increase as groundwater use increases. Those farmers with the best groundwater situations are hurt the least by the need to increase groundwater pumping, but even within one water district some farmers' groundwater costs are less than for others. For example, those farmers with an advantageous position are those closest to the surface streams and nonlined canals compared to those farmers located further away, because the groundwater table is higher and extraction costs per acre-foot are less.

[31] The Fresno Irrigation District has a superior water right compared to that of the Consolidated Irrigation District. Consolidated had averaged four to five runs in a season compared to ten to twelve for the Fresno Irrigation District, and due to lack of storage capacity the delivery season is shorter running from mid-May to mid-July. Naturally, groundwater pumping is greater in Consolidated than in Fresno.

Groundwater extraction and groundwater costs are greater in those areas which are served by water districts with smaller allotments of surface water. The more surface water delivered, the less groundwater that needs to be pumped to grow the same crop. Those farmers served by water districts with larger surface water allotments generally enjoy higher net incomes than their neighbors who must rely on groundwater pumping.

The disparity of allotments between the water districts north and south of the Kings River indicate that there is greater groundwater pumping in the southern districts. Fresno Irrigation District's allottment is 3.14 acre-feet per acre and the Consolidated Irrigation District has an allotment of 2.78 acre-feet per acre, where as the allotments of the People's Ditch Company, Lemoore Canal and Irrigation Company and the Last Chance Water Ditch Company are 2.69, 2.68, and 2.39 acre-feet per acre respectively.[32] Groundwater costs are approximately ten dollars per acre-foot higher south of the river than they are north of the river.[33] In 1968 groundwater pumping costs were $5.04 near Fresno, whereas for the Lemoore Canal and Irrigation Company the costs were $ 15 per acre-foot, and more recent[34] estimates place the cost per acre-foot in 1983 for the Fresno Irrigation District at $ 19.80

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32 Bain, Caves, and Margolis, p. 618. Allotments in the Kings River area vary from a high of 4.07 acre-feet per acre for the Laguna Irrigation District to 1.81 acre-feet per acre for the Crescent Canal and Irrigation Company.

33 See Maass and Anderson, p. 253.

34 See California Department of Water Resources, San Joaquin District, "A Method for Estimating the Value of Surface Water in Conjunctive Use Areas," Memorandum Report by W. Max Hubbart, Sacramento: Department of Water Resources, 1985, p. 14.

whereas the cost per acre-foot for the Lemoore Canal Company and the Kings County Water District combined is $23.80.[35]

In summary, from north to south there is declining surface water allotments, increasing groundwater pumping, and increasing groundwater costs. The negatiave correlation between surface water availability and groundwater costs is be expected because more groundwater must be pumped by those farmers with less surface water, assuming equal value of marginal products across all lands in the area.

II. B, 4. Surface Water Allotment in Water Districts Along the Kaweah River

Irrigation districts In the southern part of the Valley -- the areas supplied by the lower Kings, Kaweah, Tule and Kern River (see Figure 5-4) -- have had vastly different experiences than their counterparts to the north. Until entry of the federal government into irrigation development in the Valley, there was no major storage for irrigation on these rivers.[36] The canals that were constructed were able to deliver quantities of water during the relatively short diversion season far in excess of short-run crop needs, but no above-ground storage facilities nor sufficient water supplies were available for use later in the season.

[35] Differences in groundwater costs have a major influence on the willingness of a farmer to support implementation of groundwater management in his area. It is assumed that the poorer his situation with respect to groundwater availability and groundwater costs, the greater will be his support for groundwater management. Two factors, as found in the Fresno-Consolidated area, lead to this conclusion. First, if those in advantageous positions are forced to cut back on groundwater pumping, the benefit of the higher water table will fall disproportionately on those who were initially disadvantaged - those farther from a stream or canal and those whose farms overly less porous land (where the cost per acre-foot per foot of lift is greater). Second, since those in a disadvantageous situation are hit hardest in dry seasons by increased total water costs, the differentials in net farm income or profits will be made less given groundwater management which would equalizes groundwater pumping costs across farmers.

[36] California Department of Public Works, Division of Engineering and Irrigation and of Water Rights, Bulletin No. 11, p. 27.

Diversions 1n excess of crop needs were used to build up the groundwater basin, which was used later in the growing season when the water was recovered by groundwater pumping.

in the southern portion of the Valley, the limited supplies of water, particularly groundwater, were pushed to their limit causing a constraint upon the profitability of irrigated agriculture. As noted by S. T. Harding, in regards to the southern San Joaquin Valley, "the increase in area irrigated between 1902 and 1919 has been much less than for the state as a whole because of the arrival at practically a complete utilization of the surface water supply in the southern San Joaquin Valley some time between these years."[37] The relative scarcity of this water made it extremely valuable to those who possessed the right to use it, and an encouragement to the development of irrigated agriculture was made through establishing security of tenure in rights to water.

One of the rare groundwater related adjudications in the San Joaquin Valley highlights the rigidity of the existing water use pattern that is found in this portion of the Valley, and of the difficulty in overcoming that rigidity.[38] Along the Kaweah River the early landowners secured riparian rights and superior appropriation rights compared to those available to later settlers. However ,.the lands upon which these first claimants applied water was of much lower quality than subsequently occupied lands Just south of the Kaweah River. Unless water is allowed to flow to its highest and best use, such a development pattern is economically inefficient because excessive water will be applied to the low valued uses on the first-settled lands while the upstream landholders will receive too little water considering the differential in soil quality and other factors. As landowners of these higher quality lands ran short of water, the lack of a water transfer mechanism did not allow these landowners to purchase supplies from the inferior lands but they had to resort to more expensive and politically

[37] Ibid., p. 31.

[38] Bain, Caves, and Margolis, p. 459-460.

determined means. As a result, according to Bain et. al., "Landholders, to a considerable extent, have compensated for the deprivation by a heavy reliance on ground-water pumping at elevated marginal costs. As a result, the allocation of ground and surface water combined has been seriously distorted -- again because of the lack of economically appropriate transfers of surface waters.[39]

To secure water for its members, the Lindsay-Strathmore District, representing landowners upstream on the Kaweah River, purchased the Rancho de Kaweah, and along with this land, riparian rights along the Kaweah River. In addition to the riparian waters, the district Installed pumps and pipelines on the Rancho to extract groundwater from the aquifer, which is replenished by percolation from the Kaweah River. Downriver water users brought suit against the district for the use of its wellfield, and in 1925 the district was enjoined against using its wells. To replace the waters lost through the inability to use its wells, the district set out to try another avenue of water capture. The district proceeded to buy various mutual water companies and the Foothill Ditch Company, which was the highest in elevation of the companies drawing water from the Kaweah River. The district planned on taking all of its purchased shares of water through the Foothill Ditch to its lands, approximately 15 miles south of the river.

Again the water users along the Kaweah sued the Lindsay-Strathmore District and the State Supreme Court enjoined the district from initiating Its plan.[40] The basis of this 1928 ruling was that by changing the place of the diversion of Kaweah River water (from the locations used by the many mutual ditch companies to the diversion point of the Foothill Ditch it has purchased), the district had violated the riparian rights of downstream water users. Not to be denied, the district appealed the 1925 decision against use of its wellfield but lost its

[39] Ibid., p. 617.

[40] Consolidated People's Ditch Co. v Foothill Ditch Co., 205 C. 54 (1928).

appeal in 1935.[41] Paraphrasing the court's decision, Bain notes that the court "conceded the existence of ~~substantial inefficiencies~~ in the Kaweah River's tangled pattern of diversion canals, but attributed them to the historic rivalries for water within the delta. The ~~whole system was inefficient~~, but not to an unreasonable degree if the practices of individual ditch companies or irrigators were considered one by one."[42]

Following the denied appeal, and following the tradition of Miller and Haggin wherein the parties signed an agreement dividing the waters of the Kings River among themselves, the water users downstream on the Kaweah River agreed to allow the Lindsay-Strathmore district to operate its wellfield, but only until water from the Fnant-Kern Canal, which bisects the Lindsay-Strathmore District, would become available. Here is a small scale example of a surface water bailout of a groundwater overdraft problem. Rather than control the amounts of water extracted, the water users were willing to wait for surface water to be imported, and to substitute this surface water for groundwater.

The political means employed by the Lindsay-Strathmore district to obtain water were exceedingly expensive. One estimate places the cost of litigation between one and two million dollars.[43] The lack of a mechanism that allows the transfer of water to a higher and better use is a rigidity in surface water law. But because surface water and groundwater are hydrologically, economically and institutionally interconnected, rigid surface water allocations (as a result of rigid surface water law) will result in rigid groundwater

[41] Tular Irrigation District v Lindsay-Strathmore Irrigation District. 3 C. 2nd 489, (1935).

[42] Bain, Caves, and Margolis, p. 459. Italics are added.

[43] Mason Gaffney, "Diseconomies Inherent in Western Water Laws: A California Case Study," in Economic Analysis of Multiple Use, Proceedings of Western Agricultural Economics Research Council, Tuscon, Arizona, January 23, 1961, cited by Bain, Caves, and Margolis, ibid., p. 460.

allocations. The expense of overcoming these rigidities in surface water allocations present a barrier to the realization of efficient groundwater management.

II. B. 5. Summary of Early Water Districts and Surface Water Allotments

Early groundwater districts, when faced with local water shortages, attempted to augment surface water supplies by building storage dams and distribution canals. However, the availability of more surface water led to the expansion of irrigated agriculture in these early districts, and to a pattern of heavy groundwater use. It is not that these water districts suffered high groundwater costs due to overdraft; the primitive pumping technology limited the quantities of groundwater available for irrigation. Nevertheless, the rigidities of surface water allotments in these areas meant that when groundwater pumping technologies did improve, and when overdraft did become a serious problem, a more efficient allocation of the Valley's waters was impossible. Instead, water users looked outside of the Valley for additional water supplies.

Despite rigidities in surface water allocations and wide variation in their water supply conditions, local water districts proved very successful in providing water to their members. Irrigated acreage in California increased from 1,004,000 acres in 1889 to 2,644,000 acres in 1902 and to 4,220,000 in 1919.[44] The bulk of irrigation district formation was between 1918 and 1925.[45] It was the decade of the 1920's that saw the greatest amount of activity in

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[44] Hardin, p. 80. The amount of irrigated acreage in the San Joaquin Valley in "the early 1900's" is estimated at 800,000 by the San Joaquin Valley Agricultural Water Committee, p. 16.

[45] Rodney Smith, "The Economic Determinants and Consequences of the Private and Public Ownership of Local Irrigation Facilities," in Water Rights. Edited by Terry L. Anderson, Cambridge, Mass.: Ballinger Publishing co., 1983, p. 172. Statement is based on a figure developed from Michael F. Brewer, Water Pricing and Allocation with Particular Reference to California Irrigation Districts. Berkeley: California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Oct. 1960.

the financing and development of local water projects by the irrigation districts -- 43.3 percent of the capacity of storage reservoirs completed between 1921 and 1930 In northern California (i.e. that portion of the state north of the Tehachapi Mountains) was by public districts, compared to just 8.9 percent of storage capacity completed before 1921.[46] The financing of these projects, by the selling of bonds to cover construction costs and the levying of taxes to cover operating costs, limited the scale of these activities.[47] Despite the restriction on the scale of individual projects, however, the number of irrigation districts that were formed were able to undertake a sufficient number of projects so that by the middle of the 1920's, according to S.T. Harding, "nearly all of the attractive local projects had been constructed and were in at least partial use."[48]

II. C. Federal Contribution to Overdraft of Groundwater in the San Joaquin Valley

The same drought of the 1920's which led William Mulholland to increase the flow of water from the Owens Valley to the City of Los Angeles, led the state of California and the farmers of the San Joaquin Valley to look for ways to expand the quantity of water availability for irrigation. More and more farmers were resorting to groundwater to supplement their sometimes meager allocations of surface water. Water tables declined, groundwater costs increased, and some farmers were driven out of business by these higher costs. Lack of adequate water in Tulare, Kern and Fresno counties forced thousands of acres of once productive land out of agricultural use.[49] The abandonment of irrigated lands and the

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[46] Bain, Caves and Margolis, see Table 34, p. 582.

[47] The borrowing ability of any water district was limited by the size of its initial tax base rather than to the prospective payoff of its project. The result was projects designed at a scale appropriate to serve the needs of the members of the district rather than with regard to the optimal scale of projects appropriate for the river upon which the project was built.

[48] Harding, p. 83.

[49] John N. Barbour, "Water Politics in California: The Peripheral Canal Bill," unpublished Ph.D. dissertation, University of California, Santa Barbara, 1982, p. 87.

displacement of farm families stirred political efforts to find remedial measures. The state's voters supported the California Central Valley Project Act in 1933, based on the 1931 State Water Plan. The Central Valley Project was taken over by the federal government in 1935.

The rapid development of groundwater pumping in the San Joaquin Valley around the time of the first deliveries of supplemental surface water by the Central Valley Project (Friant-Kern Canal deliveries began in 1944) is described by S.T. Harding, a former State Engineer, as follows:[50]

> The 1940 census (federal census of irrigation) reported 52,000 pumping plants used for irrigation in California.... The average lift was fifty-five feet.... Fifty two percent of these pumps were deep-well turbines, 32 percent centrifugal, and the remainder miscellaneous types. Electric power was used for 80 percent of these plants, internal-combustion engines for 12 percent, and the rest were mixed types.
>
> By 1950, 45 percent of the area irrigated in California was reported to be entirely supplied by ground water and an additional 18 percent to be supplied by surface waters supplemented by ground water. These results illustrate the very extensive use that is made of ground water as a source of water supply. They also illustrate the unusually favorable ground-water conditions. In 1950 the number of plants pumping ground water had increased to 79,900, of which over 90 percent used electric power. This increase in the number of plants accounts for the greater part of the increase in irrigated areas from 1940 to 1950. From 1940 to 1950 their average lift increased from fifty-five feet to eighty-eight feet.

It is elsewhere estimated for the San Joaquin Valley that groundwater extractions, which remained stable at two million acre-feet per year between 1930 and 1940, had reached nine million acre-feet in 1955; and for the five county area including Madera, Fresno, Kings,

[50] Harding, p. 81. Particularly interesting in the above quote is the sentence, "They also illustrate the unusually favorable ground-water conditions." To the contrary, we are accustomed today of thinking of groundwater as in short supply. Also worth noting from the above quote is that since 45 percent of all irrigated acreage was irrigated entirely by groundwater, it would seem to be more correct to view surface water as a supplemental supply to groundwater, contrary to the prevailing attitude that groundwater supplements surface water.

Tulare and Kern, the 1966 estimate by the United States Geological Survey put groundwater extractions at 8,25 million acre-feet,[51]

The Central Valley Project restructured the water supply system in the San Joaquin Valley, The flow of the San Joaquin River was held behind the Friant Dam, 20 miles northeast of Fresno. The waters of the San Joaquin River are taken by the Friant-Kern Canal, which runs over 160 miles to the southeast past Bakersfield, and by the Madera Canal which runs 37 miles northwest from the Friant Dam, On the west side of the Valley, the Delta-Mendota Canal carries water from the Sacramento River over 120 miles south to the Mendota Pool at the bend of the San Joaquin River. Later, the San Luis Reservoir would be built as groundwater overdraft became a severe problem on the far west side of the Valley.

11. C. 1. District Formation and Groundwater Overdraft in the Service Area of the Central Valley Project on the Eastern Side of the San Joaquin Valley.

One main consequence of the Central Valley Project was the rapid formation of water districts in the San Joaquin Valley. The United States Bureau of Reclamation was to act as a wholesaler of water in the Valley and water districts were formed to contract with the Bureau for project water. Of the thirty-seven Irrigation Districts, California Water Districts, and Municipal Utility Districts holding permanent contracts in 1960 for service from the Bureau's canals, only six were organized before the prospect of the federal government's wholesaling activities,[52] The other 31 were formed exclusively to contract with the Bureau for its supplemental surface supplies.

Falling groundwater tables had a large influence on the formation and location of these groundwater-deficient districts. The following is a list of the groundwater characteristics of

[51] San Joaquin Valley Agricultural Water Committee, p. 20,

[52] Bain, Caves, and Margolis, p, 301.

selected irrigation districts that were formed to receive water from the Friant-Kern Canal, the year they were formed, and the depth to groundwater in feet at the time of formation.[53]

DISTRICT	YEAR	DEPTH (IN FEET)
ORANGE COVE	1937	80-100
EXETER	1937	75-130 .
LINDMORE	1937	200
SHAFTER-WASCO	1937	75-100
DELANO-EARLIMART	1938	150-280
SAUCELITO	1941	120
IVANHOE	1948	75
STONE CORRAL	1948	44
LOWER TULE RIVER	1949	83
PORTERVILLE	1949	55

Note that districts formed before World War II had significantly greater pump lifts than those formed later. The demand for water became greater after World War II because of the post-war agricultural boom in the Valley. This boom threatened to worsen groundwater conditions and encouraged districts with groundwater depths approaching, but less than, 100 feet to sign-up for Friant-Kern water. Another encouragement was that the longer these districts waited to sign contracts for Friant-Kern Canal water, the greater became the chance that the available water would become tied up in contracts leaving no water for them to receive. The combined effects of quickened rates of decline in the groundwater table and the fear of losing a possible water allocation created an incentive for these districts to sign surface water contracts before water depths reached the same depths as in those districts who signed water supply contracts before the war.

Most water districts in the eastern and southern portions of the Valley were formed to receive water stored behind the Friant Dam which was built on the San Joaquin River. The prospect of having surface water to substitute for groundwater was the catalyst that led to their formation. Kern County had few water districts before the appearance of the Central

[33] Source is Table 22, ibid, p. 209.

Valley Project because lands in this county were in large ownerships which had long since allocated among themselves the waters of the Kern River. But with the prospects of federally subsidized water, water districts such as the Semitropic, Rosedale-Rio Bravo, and the Wheeler Ridge-Maricopa, were formed by the large landowners despite the 160-acre limitation in the Reclamation Act of 1902 which should have required these large landholders to sell off their "excess lands" if they were to receive Bureau water.

The Bureau provides all water users, large and small, with subsidized water.[54] The subsidy has many forms, such as the use of revenues from the sale of electrical power to repay capital costs of the water project, the use of fixed charges for transportation costs regardless of the distance the water travels between dam and farm (i.e. "postage stamp" transportation costs), and the setting of water charges based on the "ability to pay" of the irrigator. The subsidized surface water price has two effects on groundwater usage. First, compared to a situation where either surface water is not subsidized or is not available, more groundwater is used on lands with access to both subsidized surface water and groundwater, and secondly more lands are brought into production which further increases the total amount of groundwater used.

To show how the availability of surface water can increase use of groundwater on existing lands (the intensive margin), suppose irrigators use 5 acre-feet of water per acre to grow a crop worth $50 per acre (net of non-water costs), and this crop can be grown in more

[54] Subsidy to large landholings in excess of the 160-acre limitation of the Reclamation Law of 1902 are of two types. One is non-enforcement of the acreage limitation. Another is the irrigation practices of these large land owners. With the availability of Bureau surface water, the large landowners could apply Bureau water to non-excess acreage, and then pump groundwater to supplement the surface water used on the non-excess acreage. Furthermore, they could irrigate a portion of their excess lands by over-applying surface water on their non-excess lands and then pumping this water, after it percolates underground, for use on excess lands. The CYP thus subsidizes large landowners because it allows them to use Bureau water on a portion (non-excess acreage) of their lands, and then reuse it on their excess acreage by applying only groundwater -- whose extraction cost is now cheaper because of the return flow of the federal water -- on the excess acreage.

than one rotation during the growing season. Further suppose that surface water is subsidized at $7.50 per acre-foot and groundwater is $ 10 per acre-foot, and the irrigator has an allotment of 7.5 acre-feet of surface water per acre. On the first rotation he will use all surface water, so for a water cost $37.50 he produces a crop worth $50 and makes a profit of $6.50 per acre irrigated. This leaves 2.5 acre-feet of surface water to use on the second rotation (a rotation here can be another section of the same farm upon which a full 5 acre-feet of water Is not available) which will result in a surface water cost of $ 18.75 and a groundwater cost of $25.00 for a total water cost of $43.75 and a per acre profit of $6.25. A third rotation is not undertaken because no profit will be earned from it, since the water costs of $50 will equal the revenue and zero profits are earned. Across both rotations of the growing season (or across both sections of the farm), the average water costs were $40.63 and the average profit per acre was $6.38. As long as any surface water can be mixed with the more expensive groundwater it is profitable for the farmer to use groundwater, whereas if only groundwater were available it would not be profitable to use It. Because the surface water costs are subsidized, the farmer is willing to incur the use of groundwater (which at the margin is more expensive) and to raise the average cost of groundwater to increase the amount of crops grown. The same average total water costs would be incurred and less groundwater extraction would take place as surface water costs approach groundwater costs. Subsidized surface water encourages farmers to overuse groundwater, and this use contributes to groundwater overdraft.

In addition to the increased groundwater use on the Valley's existing farms due to subsidized water prices, new acreage was brought under irrigation given the availability of subsidized CYP water. Though the original purpose of the Central Valley Project was to provide supplemental water to already irrigated acreage, the availability of surface water made it profitable to turn vast acreage in the Valley from dry farming to irrigated agriculture.

The extensive margin of irrigated agriculture expanded greatly under the influence of the Central Valley Project. Because of the hope of receiving water from the Bureau's projects, irrigation began on lands that had access to only dwindling groundwater resources. Bain, et. al. show how the district formation process encouraged some areas to rely on groundwater:[55]

> As indicated above, the first districts to organize in the San Joaquin Valley were those with the most unsatisfactory ground-water conditions. This process continued as the canals were built, with districts forming to fill the "holes" among organized agencies until the lands which could be economically served by the canals were fully covered. Even after the Bureau of Reclamation had entered into contracts for all of its available supplies, new districts kept forming in the hope that supplementary facilities would be built to serve the area. The Bureau of Reclamation has maintained a priority list of late applicants for any supplies becoming available in the future, and surface water may occasionally be available to them in wet years.

These waiting districts, as well as others with overdraft problems, are waiting for a surface water bailout of their problem and are unlikely to accept as fair any restriction upon groundwater pumping.

Many areas are "unorganized" and they present a special problem for the establishment of efficient groundwater management in the San Joaquin Valley. The situation of these unorganized areas is explained by Andrews and Fairfax as follows:[56]

> These areas occur in a patchwork pattern throughout the Valley. Typically they have remained unorganized because they lack surface water supplies to distribute among their users. In other cases nominal districts have been formed, but they are nonfunctional because their anticipated surface supplies never materialized. The unorganized areas may depend heavily on groundwater pumping to the detriment of the organized districts' recharge efforts.[57] In short, the unorganized areas are gadflies which complicate the current local water management scene.

[55] Bain, Caves, and Margolis, p. 301.

[56] Andrews and Fairfax, p. 199.

[57] A good example is the Raisin City Water District, located just to the west of the City of Fresno, and which relies heavily on groundwater because it never received a surface water supply. This situation has prompted the Fresno Irrigation District to initiate local efforts to enact groundwater management legislation.

Subsidizing surface water costs as a solution to the problem of groundwater overdraft makes the same mistake as treating the symptom of a disease rather than its cause. Groundwater overdraft results in high groundwater costs, and though subsidizing surface water costs lowers the cost of water to irrigators, it does nothing to eliminate the cause of groundwater overdraft. Though farmers have exhibited a willingness to take collective action to secure surface water, they have not been willing to collectively control use of groundwater, Overdraft results because of the common property rights to groundwater and the inefficient decisions made by individuals who use the common property resource. Providing more surface water may temporarily alleviate overdraft only if farmers substitute surface water for groundwater. Inevitably, additional supplies of water lead to expansion of irrigated land and continued groundwater pumping, especially when encouraged by subsidized surface water prices, and an eventually return to the previous overdraft condition.

The result of surface water importation has not been a lessening of the overdraft problem, but it has added to the web of entangled surface water contracts that make the implementation of groundwater management extremely difficult. Surface water contracts and surface water delivery systems do not recognize the interdependence of surface water and groundwater. instead of efficiently allocating surface water by delivering where it would be the most productive, the basis of allocation of surface water became the political and economic strength of farmers who were competing among themselves for the available supply.

11. C. 2. District Formation and Groundwater Overdraft in the Service Area of the Central Valley Project on the West Side of the San Joaquin Valley

On the west side of the San Joaquin Valley, the San Luis Reservoir of the Central Valley Project serves some of the largest landowners in the Valley. However, unlike the situation that exists in the southern portion of the Valley, the previous overdraft of the district's groundwater basin has been, at least at present, near zero.[58] However, without controls on groundwater use nor on development of irrigation on new land, overdraft is expected to return. The pattern of the response to groundwater overdraft was the same on the west side of the San Joaquin Valley as elsewhere -- rather than creating institutions to control the common property aspects of groundwater use that result in groundwater costs high enough to drive irrigators out of business, the irrigators obtained subsidized surface water to reduce the quantity of groundwater use. This pattern in the context of west-side water development will be discussed below.

The San Luis Unit of the CVP is a joint federal-state venture. The San Luis Canal is that portion of the California Aqueduct between the San Luis Dam and Kettleman City. Below Kettleman City, the California Aqueduct becomes a state-only project. Of the 1.26 million acre-feet of entitlements from the San Luis Canal ,1.1 million acre-feet of entitlements belong to the Westlands Water District.[59] The 63,000 acre Westlands.Water District was organized in 1952 to secure surface water imports.[60] Despite the ownership of land in excess

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58 Andrews and Fairfax, p. 215. Overdraft was 800,000 acre-feet in 1962, but with the CVP surface water allocation of 900,000 acre-feet per year as of 1975 and a 100,000 acre-feet safeyield, this overdraft was eliminated. However, another 500,000 acre-feet will be needed if all of the district's prime agricultural land becomes irrigated.

59 See Table 7, San Joaquin Valley Agricultural Water Committee, p. 22.

60 In 1964 the Westlands Water District absorbed a neighboring area of 190,000 acres that until this time has hoped to receive water from the State Water Project. See Mark Reisner, Cadillac Desert. New York: Viking Penguin, Inc., 1986, p. 175.

of the Bureau of Reclamation's guidelines, the Westlands Water District was able to secure subsidized water from the Central Valley Project.[61]

After delivery of CVP water, groundwater extraction in the Westlands Water District fell from a high of approximately one million acre-feet to about 100,000 acre-feet.[62] The district had no difficulty in marketing its surface water supplies because the price of the subsidized water was well below the cost of groundwater extraction. However, the district's supply is inadequate to provide all water needs of the district's lands (if the supply were spread evenly over the district, only 1.8 acre-feet per acre would be available), so overdraft of groundwater is to be expected in the future.

In 1968, it was predicted that in response to the delivery of CVP water, the Westlands' landowners would increase the production of cotton (from 130,464 to 152,000 acres), sugar beets (from 6,107 to 39,000 acres), fruit trees (from 680 to 39,000 acres), and alfalfa hay (from 8,461 to 30,000 acres), or in other words that acreage in these four crops would increase 178 percent as a result of the water imports.[63] In 1980 the acreage in these crops are 277,400 acres, 9,000 acres, 7,700 acres, and 29,700 acres, respectively, which shows a 222 percent increase.[64] This reallocation of water use between the projected

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[61] U. S. Bureau of Reclamation, Feasibility Report on the San Luis Units. Washington, D. C: U.S.G.P.O., 1955, p. 89. See Mark Reisner, ibid. Of the original 440,000 acres in the Westlands Water District on the west side of Fresno County, 83 percent of the land in the district was owned by 130 people or corporations, 74 percent of the land was in the hands of 66 owners, and nearly one-third of the district's land was owned by just four landowners. In comparison, the Fresno, Consolidated and Alta irrigation districts which are on the east side of Fresno county, have less than one percent of the total numbers of owners who are classified as excess-land owners.

[62] California Department of Water Resources. The California Water Plan. Bulletin 160-83, Sacramento: Department of Water Resources, 1983, p. 124. Also see San Joaquin Valley Agricultural Water Committee, p. 60 which reports overdraft in 1976 was 97,000 acre-feet.

[63] This is according to a 1968 statement by the Westlands Water District. See Nark Reisner, p. 176.

[64] California Department of Water Resources, Bulletin 214, p. 65, see Table 12.

to the actual represents a relatively greater emphasis on crops with a higher applied water requirement, which is to be expected given the subsidized water prices.[65] Nevertheless, given this increase in irrigated acreage on the extensive margin, groundwater overdraft is expected to increase above its present level in the near future.

II. D. West Side San Joaquin Valley and the State Water Project

Kern County has less surface water than other counties of the San Joaquin Valley. Despite this limitation, farming expanded from 200,000 acres in the mid-1930's to 700,000 acres in 1960. Similarly, overdraft problems also expanded. Groundwater that in 1932 could be reached at 55 feet below the surface had dropped to 250 feet by 1960 because of the over two million acre-feet of water extracted from the groundwater basin; 725,000 acre-feet of it was due to overdraft.[66]

The State Water Project was another surface water import program in response to groundwater overdraft. The combined strengths of the agricultural interests in Kern county and the urban interests in southern California provided the impetus needed for the voters of the state to approve construction of the Oroville Dam and the California Aqueduct as initial parts of the State Water Projects. The California Aqueduct of the SWP delivered a maximum of 1,800,918 acre-feet in 1979. However, in most years, the amount of delivery is above the amounts agreed to in the contracts between the water districts and the Department of Water Resources because the DWR has surplus water. In some years, such as 1983, the deliveries are below the contracted amounts because excess rainfall makes such purchases by the

[65] Cotton and alfalfa hay required 3.6 and 4.6 acre-feet per acre, respectively, whereas fruit trees and sugar beets require less water per acre (almonds and postachios require 2.9 acre-feet per acre, miscelaneous deciduous trees require as much as 4.1 acre-feet per acre, and sugar beets require 3.7 acre feet per acre). See Ibid., Table 13, p. 67.

[66] Cooper, p. 164.

Irrigators unnecessary. (If adequate replenishment programs had been in place, the water could have been recharged underground for future use. The Kern Water Bank is a program designed to correct this problem.) Below is a list of contractors for SWP water and their contract entitlements.[67]

Water District	Maximum Annual Entitlement in acre-feet
Devils Den Water District	12,700
Dudley Ridge Water District	57,700
Empire West Side Irrigation District	3,000
Hacienda Water District	8,500
Kern County Water Agency	1,153,400
County of Kings	4,000
Tulare Lake Basin Water Storage District	110,000
TOTAL	1,349,300

There are substantial differences in the annual deliveries of SWP water to Kern County. During the drought year of 1977, water deliveries were only 529,079, and during the extremely wet year of 1983, water deliveries were 672,068. Total irrigated acreage in the service area does not fluctuate as much as does the deliveries of water. Farmers rely heavily on groundwater pumping in dry years and local surface diversions in wet years to maintain the same irrigated acreage.[68] In wet years most water districts are allowed to carry-over their entitlements to later years when the water will be needed. The Kern County Water Agency has no such wet weather provision in its contract, and so takes as much of Us yearly entitlement as it can, but in 1983 it took only 74$ of its 805,100 acre-foot entitlement.

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[67] San Joaquin Valley Agricultural Water Committee, Table 10, p. 23.

[68] State of California, Department of Water Resources," Management of the California State Water Project," Appendix F. San Joaquin Valley Post-Project Economic Impact, 1983, Bulletin 132-84, Sacramento: Department of Water Resources, December 1984, p. 5.

Kern County's overdraft was estimated to be 700,000 acre-feet annually by the late 1950's. The Kern County Water Agency was formed In 1961 to contract for supplies from the State Water Project, and delivery began in 1968.[69] The Kern County Water Agency overlays the entire county, thus gaining access to the tax base of Bakersfield, the county's major urban center, but only districts receiving SWP are member districts of the KCWA. Many farmers as well as Bakersfield opposed the SWP because of its high water prices, but because the SWP provided surface supplies they were in need of, and without acreage limitations, the local interests agreed to join the KCWA. The member districts in the KCWA determine the allocation of imported surface water throughout the county, and the KCWA acts as a water providing agency rather than a policy setting agency.[70]

The consequence of the SWP on the agricultural environment of surrounding Kern county is little different than the effect the CVP had on the east side of the San Joaquin Valley. Despite the expectation that imported surface water would correct the overdraft problem, expansion of irrigation onto previously dry-farmed land caused an increase in groundwater pumping, and continued overdraft. As explained by Andrews and Fairfax:[71]

> An understanding of the relative costs between surface and groundwater in Kern county is necessary to appreciate the impact of surface water deliveries from the SWP on groundwater pumping in the county. Because a major purpose of the SWP was to relieve overdraft, the KCWA, as the county's water distribution agency, established an 'overdraft correction' program to allocate

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[69] Districts in the Kern County Water Agency include the Belridge Water Storage District, Berrenda Mesa Water District, Buena Vista Water Storage District, Cawelo Water District, Henry Miller Water District, Improvement District No. 4 (Bakersfield), Lost Hills Water District, Rosedale-Rio Bravo Water Storage District, Semi-tropic Water Storage District, Tehachapi-Cummings County Water District, West Kern Water District and Wheeler Ridge-Maricopa Water Storage District.

[70] See Henry Vaux, "Water Scarcity and Gains from Trade in Kern County, California," in Scarce Water and Institutional Change, edited by Kenneth D. Frederick, Washington D. C: Resources for the Future, Inc., 1986, pp. 79-80, and Andrews and Fairfax, p. 225. The City of Bakersfield is within Improvement. District No. 4, and because it is an improvement district, its property can be taxed at a higher rate than the surrounding land.

[71] Andrews and Fairfax, p. 227-8.

> surface water first to municipal uses, and second to the established agricultural economy. New irrigation was given last priority so that new surface water could be allocated to offset existing pumping. However, when the local districts negotiated for state water in the mid-1960's, many of them found it significantly cheaper to pump groundwater than to buy surface water[72] Accordingly, there was inadequate demand for the SWP water from the established agricultural economy, and the KCWA was forced to market the state water to new agricultural development. Two sizable SWP allocations, for example, went to newly developed lands on the county's west side -- the Berrenda Mesa Water District and the Belridge Water Storage District -- neither of which overlie usable groundwater. Overall, therefore, contrary to early expectations, the SWP encouraged agricultural expansion and was not effective in getting farmers to reduce pumping.

A few districts provide examples of the character of water distribution systems in this portion of the Valley and how groundwater use is affected by surface water imports. The Arvin-Edison Water Storage District was formed in 1942 to receive mostly Class 11 water from the Friant-Kern Canal of the CYP.[73] The district's contract calls for 40,000 acre-feet of Class I (i.e. firm) water and up to 313,000 acre-feet of Class II (i.e. surplus) water, yet average delivery has been 191,000 acre-feet. Its surface water distribution system covers 40 percent of the district's Irrigated acreage (the remaining 60 percent of the district's irrigated acreage rely exclusively on groundwater), and all farmers served by surface water no longer pump their own groundwater. In dry years when surplus water is not available and the district's surface water supplies fall to its Class I allotment, the district uses its own wells to pump groundwater into its surface water distribution system.

The SWP has also allowed for contractual arrangements that will complicate any attempt at efficient groundwater management. Since surplus water was available in the

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[72] Cf. The Arvin-Edison Water Storage District provides a ready example of the relative groundwater costs of the period. Its pumping costs were estimated at $16.83 in 1960. At the same time, farmers at the southern end of Kern County were facing SWP prices of approximately $ 18.00 per acre-foot.

[73] The Bureau of Reclamation contracts for two types of water: Class I water which is "firm" water, and Class II water which is available only during wet years in which a surplus of water above Class I contracts exists. Class II water was designed to replenish groundwater basins, but it is generally used to grow additional crops.

California Aqueduct, many districts in Kern County financed the Cross Valley Canal which was to connect the SWP with the CVP, and to allow interchange of water between districts.[74] The Canal allows CVP water to be delivered from the California Aqueduct to Bakersfield, and to the Arvin-Edison Water Storage District. The Arvin-Edison Water Storage District has an exchange arrangement with Cawelo, Rag Gulch, and Kern-Tulare water districts in Kern County as well as with districts in Tulare and Fresno Counties.[75] To firm up its surface water supply, the district entered into an exchange program in 1974 whereby it receives 128,300 acre-feet from the California Aqueduct via the Cross Valley Canal, and in turn it releases 174,300 acre-feet of its Friant-Kern Canal water to other districts.[76]

Similar to the Arvin-Edison Water Storage District's surface delivery pattern, the North Kern Water Storage District has 60,000 Irrigated acres, half of which are served by the district with surface water and half relying solely on groundwater. The district receives its surface water from the Kern River, which has a wide variation in flow (from 25,000 acre-feet to 300,000 acre-feet). In dry years the district's 52 wells pump water from out of the ground to make up for the shortfall of surface water. Groundwater pumping has varied in recent years from zero to 65,000 acre-feet.[77] Likewise, the Semitropic Water Storage District has only groundwater and surface water from the KCWA to supply its 120,000 irrigated acres. Two improvement districts, covering 70 percent of the district's 224,000

[74] Another factor that allows water exchanges is the Kern River Intertie. It connects the Kern River with the California Aqueduct. In the wet year of 1983, 759,055 acre-feet of Kern, Kaweah, and Tule River floodwater entered the California Aqueduct for use elsewhere. See California Department of Water Resources, Bulletin No. 132-84, p. 4.

[75] These include Hills Valley Irrigation District, Tri-Valley Water District, Hope Water District, Ducor Irrigation District, Lower Tule River Irrigation District, and Pixley Irrigation District.

[76] For descriptions of this exchange program, see San Joaquin Valley Agricultural Water Committee, p. 52-3, Henry Vaux.p. 80-2, and Andrews and Fairfax, p. 230.

[77] San Joaquin Valley Agricultural Water Committee, p. 58.

acres, were established in 1965 -- the Buttonwillow improvement Districts and the Pond-Poso Improvement District -- to account for their serious groundwater depletion problems. Again, as throughout the rest of the Valley, additional acres have been put to irrigation due to the presence of imported surface water, and on these and all irrigated acres overlying groundwater, groundwater pumping increases in years of low SWP deliveries and decreases in years when surplus water is available,

A recent proposal; called the Kern Water Bank, will permit SWP water to be recharged, stored, and extraced by the SWP for future use. The main purpose of this program is to increase the safe yield of the SWP but it also has substantial groundwater use consequences, and should prevent a reoccurance of what happened in 1983. Recharge areas, operated in conjunction with the City of Bakersfield, will allow capture of surplus local water that will otherwise be diverted to the California Aqueduct or flood Tulare Lake farmlands. New delivery facilities will deliver water to presently unserved farmlands, and instead of extracting groundwater the irrigators on these lands will use SWP water which will pecolate underground. The SWP will receive water storage credit for the groundwater that is not pumped due to its deliveries.[78]

II. E. Summary and Conclusion to Surface Water Augmentation as a Policy Response to Groundwater Overdraft Problems

The above sections on the characteristics of the San Joaquin Valley's surface water delivery system shows that the development of surface water supplies by local water districts

[78] See California Department of Water Resources, Bulletin 160-87, p. 48.

differed from the subsequent development undertaken by the federal and state governments.[79] The Stanislaus, Tuolumne, Merced, and Chowchilla rivers were developed exclusively by local water districts, which built large storage facilities to provide irrigation water. Though the San Joaquin, Kings, Kaweah, Tule, and Kern rivers have important local water allocation arrangements, no local water district or group of water districts were able to build water storage facilities. The storage facilities on these rivers were built by the federal government as part of the Central Valley Project.

Two characteristics of the surface water supply system stand out. The first is the variety of conditions under which water is used. Regardless of whether a local water district or a central government is responsible for surface water storage and distribution, the amounts of water, in terms of the number of acre-feet per acre of irrigated land, differs across many water districts. Also, the depth to groundwater and hence groundwater extraction costs differ across water districts, and furthermore, the conditions under which surface water deliveries are made available to farmers in various water districts also differs across the San Joaquin Valley. These differences make more numerous and complex the decisions that must be made and the agreements that must be struck if efficient groundwater management is to be instituted in the San Joaquin Valley.

The second characteristic of the surface water supply system is the rigidity with which water allocations become established. Characteristics of both the riparian and appropriation doctrines, restrictions against transfers of water, and the long-term contractual arrangements that govern the water allocation in most rivers of the Valley, all tend to consign or adhere the water to the land upon which it is used and to prevent the

[79] For an analysis of the efficiency with which the local versus federal water projects were developed, and of a consequence of the timing of this development, see Joe S. Bain, "Water Resource Development in California," in Water Resources Management and Public Policy, edited by Thomas H. Campbell and Robert O. Sylvester, Seattle: University of Washington Press, 1968, pp. 12-29.

transfer of water to that land upon which Us use is most valued. The rigidity of surface water usage patterns causes groundwater overdraft to be concentrated in areas of deficient surface water supply. Because of these rigidities, increases ingroundwater costs due to continued groundwater overdraft does not result in a reallocation of surface water away from its present (i.e. lowerer valued) use and toward those areas most willing to pay for it (i.e. those areas with high groundwater costs). The inflexible surface water allocation pattern is a constraint to efficient groundwater management in that since this inflexibility implies an inefficient allocation of surface water, gains from creating institutions that result in efficiency only in groundwater use are less than if both sources of water were efficiently used.

III, Pricing Policies of Water Districts as Constraints to Groundwater Management

III. A. Introduction

The primary purpose of a water district is to pool economic resources to acquire as cheap and as dependable a water supply as is possible for the benefit of the member water users. Water districts must bear the costs of these activities, but the particular ways water delivery is financed is a decision made by the individual water districts. Generally, districts rely on (1) user charges per acre-foot of water actually delivered; (2) special benefit assessments on lands whose values are directly enhanced by district water programs; (3) general property taxes on all property within district boundaries, whether serviced by the district or not; and (4) bond sales. California's constitutional tradition guarantees water districts a substantial degree of independence in their governance, and the result is a wide varietal mixture of the above four finance mechanisms.

The cost of groundwater extraction is an important determinant in how water districts cover the cost of their irrigation operations, because the members of water districts can often resort to groundwater as an alternative source of water supply and to thus avoid paying for surface water. Groundwater puts a ceiling or cap on the price, per acre-foot of surface water, many water districts charge,[80] because if surface water is priced above the cost of groundwater, farmers will obtain irrigation water from their wells rather than from the water district's canals. The comparative cost levels of ground and surface water determine the relative amounts of eacy type of water used. There is an implicit rivalry between these sources of supply. The terms of the competition and the prices of surface and groundwater will be shown to widely vary throughout the San Joaquin Valley.

This section of the chapter looks at the pricing behavior of some of the districts in the Valley to highlight the various ways in which water is priced in different regions of the Valley. Water is allocated inefficiently because prices are not set equal to the cost of acquiring additional units of water. Furthermore, prices are not used to deliver water to its highest and best use. The relationship between pricing structures in the Valley and water allocation is summarized by Henry Vaux, the present head of the University of California's Water Resources Research Center, as follows:[81]

> The fact that the prices of surface water are structured to recover cost and induce conjunctive use of ground and surface water means that , in many instances, prices do not serve a rationing function. The basic allocation and rationing functions are accomplished through the formal system of entitlements (both legal and contractual) and ultimately through the availability of water. In years when water is plentiful, deliveries to districts and within districts are governed by contractual entitlements to both firm and surplus water and by the system of legal entitlements that governs the use of ... water. In water-short years, the rationing of surface water is usually governed by the availability of groundwater, with available surface supplies being directed to areas that have no access to groundwater.

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[80] Retaining the assumption of water districts as users' cooperatives, the above analysis assumes the price a district sets on water is a charge the farmers impose on themselves. To maximize their joint profits, the farmers will set the cost of water as low as possible while still allowing for fixed and variable costs, including depreciation of capital, to be covered.

81 Vaux, p. 87-88.

Both groundwater and surface water are scarce, causing Individuals to compete to secure a portion of the total supply. The means of rationing the scarce supplies of water are surprisingly different given their substitutability in performing the same function. Groundwater is priced implicitly by the farmer according to his cost of extracting each acre-foot of water. The cost the individual farmer is willing to bear for each acre-foot of groundwater is a private decision made according to his individual water use situation. However, the decision as to surface water use and price is made collectively by the members of the water district by either a direct vote by the farmers or by a board of supervisors appointed by the farmers to make that decision. For the use of water to be efficient, it must be that the price of water equals its long-run marginal cost, thus causing it to be used in its highest and best use. As the highest and best use changes with time, so must the use of water. As will be shown below, it is often the case that surface water pricing policies result in water allocations that are very rigid, so that water is not allowed to flow to its highest and best use over time.

Relative cost differences are as important as the cost levels in determining the allocation of water use in the short run among the two alternative sources of supply: groundwater and surface water, if the source of supply with the higher long-run total cost offers the lower variable costs in the short run (through a pricing structure which covers a portion of the fixed cost by some means which does not influence the irrigator's water use decision), significant problems of efficient allocation may result. As will be shown below, many districts engage in water pricing activities which do not communicate to the water user the full marginal cost of using surface water. Because surface water prices are "distorted," so Is the allocation of water use between surface water and groundwater as well as the total level of water use likewise distorted (i.e. inefficient).

Surface water supply systems are characterized by high fixed costs because the technology of surface water supply requires large dams and miles of canals. Once these structures are in place, the cost of delivering each acre-foot of water is negligible. The high fixed cost nature of the industry led to the failure of early private efforts to supply water and the reliance upon public districts with the power to Issue bonds and raise taxes. The presence of high fixed costs suggests that the water districts must have a constant and steady flow of revenue to cover their financial obligations. Given high fixed costs and the wild fluctuations in the year-to-year water flow of California's rivers, the water districts developed institutions to prevent the uncertainty in water supply from creating financial insecurity. Water districts have used property taxes to cover a large portion of their revenue needs, been willing to enter into long-term contracts to assure long-term water deliveries at constant prices, and they have avoided bargaining over the sale of water by putting restrictions on the transfer of water out of the district. The average cost for surface water across 85 water districts in the Valley was $ 14.51 per acre-foot (the average variable cost was $ 12.12 per acre-foot), but as explained below, these are subsidized prices.[82]

The relationship between surface water's fixed cost and variable cost and how price is related to these is an institutional decision made by the members of each water district. Because groundwater is, for the most part, privately extracted by individual farmers (i.e. the final users), institutional inefficiencies do not distort the price of groundwater. The cost of groundwater extraction increases about proportionally with the height of the pump lift -- the lower the water table the higher the variable cost of extraction. In the early 1960's, the average total cost per acre-foot of water pumped ranged from $2.39 to $22.64. These costs to private pumpers were from 55 to 70 percent fixed costs, and 45 to 30 percent variable costs, with the median tendency at about 60 percent for fixed costs (treating only repair and

[82] See San Joaquin Valley Agricultural Water Committee, p. 37-9, Table 7 and Table 8.

maintenance and the variable energy charge for electricity as variable costs).[83] After nearly twenty years, the average groundwater pumping costs have gone up, but the percentages of fixed and variable costs remained the same.[84]

Because groundwater pumpers pay both the fixed costs and variable costs of groundwater extraction, the private long-run marginal costs of groundwater use are borne by the private pumper (ignoring for the moment the common property problem). Such is not the case for surface water use. One incentive for the formation of water districts to supply surface water is that property taxes can be applied to lands that do use surface water. Thus, non-water users bear part of the cost of water provision, and the water user does not pay the full cost for surface water use. Certain provisions of water supply by the federal government also result in the general taxpayer paying part of the cost of the Central Valley Project, which also results in water users not paying a price for surface water that equals its long-run marginal cost.

Though individual pumpers pay the variable and the fixed costs of groundwater, this does not mean that their total water use, nor necessarily their use of groundwater, is efficient. Distortions in surface water prices can prevent total water use and groundwater use from being efficient. These distortions occur because surface water prices are often subsidized by

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83 Bain, Caves, and Margolis, p. 204.

84 According to Allan Highstreet, Carole Frank Nuckton, and Gerald L. Horner, Agricultural Water Use and Costs In California, Giannini Foundation Information Series 80-2, Berkeley: University of California, 1980, the average groundwater costs per acre-foot in Stanislaus and Merced counties was $21.95; in Fresno, Madera and Tulare counties it was $27.87; and in Kern and Kings counties it was $33.72. For the San Joaquin Valley as a whole, the average groundwater cost was $30.00 per acre-feet, with a range from $ 12.84 to $74.52 per acre-foot. According to W, Max Hubbart, "Statewide Planning Program Central Valley Water Management: A Method for Estimating the Value of Surface Water in Conjunctive Use Areas," a Memorandum Report by the San Joaquin District of the Department of Water Resources, Sacramento; Department of Water Resources, 1985, whereas water prices ranged from a low of $ 17.50 per acre-foot to a high of $94.00 per acre-foot; the percent of energy costs per acre-foot as a percent of the total cost per acre-foot ranged from a low of 44% to a high of 70$ with an unweighted average of *54%.*

the revenue generated from the sale of electric power, by charging for surface water based upon the irrigator's ability to pay (even if this is below the cost of delivering water), by not charging interest on the capital facilities used for water storage and delivery, etc.[85] Furthermore, surface water costs, particularly the cost of water from the U. S. Bureau of Reclamation's Central Valley Project, are determined by long-term (i.e. 40 year) contracts that do not allow the price of water to Increase to reflect either the effects of inflation or, more importantly, water's increased relative scarcity. Even if the price of water had been efficiently determined at the time of the contract, the rigidity in upward price movements would deprive the price of any continued efficiency characteristic.

In a study of the Central Valley Project's rate setting policy, King and LeVeen identify three subsidies which cause the water price charged by the Bureau to be too low.[86] The first is the use of long-term contracts at fixed rates which do not allow for increased operation and management costs due to inflation nor for including the increased cost of new water supplied by the construction of new projects. The Bureau charges irrigation customers an average of $4,00 an acre-foot, whereas the current operating costs alone have increased to $5,60 per acre-foot. The second subsidy is the use of the ability to pay formulas in calculating the water charges to the water districts. Not only did the Bureau neglect to include the influence of

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[85] Bain, Caves, and Margolis, p. 206, estimate, based on calculations in their Appendix C, that"(Ootal capital and current costs should thus average from $6.20 to $7.00 per acre-foot with a 2 per cent depreciation rate and a 4 per cent interest rate, and from $5.05 to $5.65 with a 1 per cent depreciation rate and a 4 per cent interest rate.... These costs compare to a flat-rate wholesale price of the same water of $3.50 per acre-foot in the area." As for the $3.50 per acre-foot price, they say, on page 469, that "...in view of the importance of this price, there is no public account of the process by which it was set." But they speculate that two major factors led to the setting of the $3.50 price. The first was the expected ability of the farmer to pay for the water, and the other was covering with revenues from the sale of power and municipal and industrial water in excess of the costs imputed to them, those costs of the project allocated to irrigation from all of its service areas taken together. (See page 469).

[86] See Laura B. King and E. Phillip LeVeen, Comments of the Natural Resources Defense Council, Inc. on the Bureau of Reclamation's CVP Rate-setting Policy Proposal, San Francisco: Natural Resources Defense Council, Inc., August 1984.

overdrafted groundwater basins in its calculations, but the Bureau in California has a policy of setting a limit for rates equal to 75 percent of irrigations districts' estimated ability to pay.[87] The third is the "power subsidy" in which the operation and management costs are undercharged for power used by the Bureau to operate its pumps (I.e. conveyance costs). This subsidy amounts to from $2.26 to $7.07 per acre-foot, depending on the district.[88]

Both surface water prices and groundwater costs vary widely throughout the Valley. According to one study,[89] In the northern portion of the Valley, Stanislaus and Merced counties, the average price of surface water from local irrigation districts was $3.75 per acre-foot and from the Bureau the average price was $4.70 per acre-foot; whereas groundwater's average price was $21.95 per acre-foot. In the central counties of Fresno, Madera, and Tulare, local canal and ditch companies price water at an average of $7.00 per acre-foot, and the Bureau charges an average of $ 13.50 per acre-foot, whereas groundwater is available at $27.87 per acre-foot. On the west side of the Valley, In Kern and Kings county, local districts, many with rights to flow from the Kern River, charge $ 15.00 per acre-foot, water from the Central Valley Project costs $24.00 an acre-foot; and water from the State Water Project costs an average of $46.50 per acre-foot, whereas groundwater is available for $33.72 per acre-foot.

Surface water costs to the water districts within the same region of the Valley are held relatively constant by the contracts of the Bureau. In contrast to the variation in surface

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[87] See ibid., p. 17, footnote 17, which refers to U. S. Bureau of Reclamation. CVP Rate-setting Policy Proposal, (April, 1984).

[88] One study estimates that the sale of electric power subsidized 11.1 percent of the irrigation costs in the Central Valley Project. See Randal R. Rucker and Price V. Fishback, "The Federal Reclamation Program: An Analysis of Rent-Seeking Behavior," in Water Rights. edited by Terry L.Anderson, Cambridge, Mass: Ballinger Publishing Co., 1983, p. 62.

[89] See Highstreet, Nuckton, and Horner.

water prices, groundwater prices can vary even more substantially across the Valley,[90] For example, in 1980, average pumping depths were 96 feet for the Kings County Water District, 113.7 feet for the Lower Tule River Irrigation District and 504 feet for the Arvin-Edison Water Storage Districts. It costs $73.50 per acre-foot to pump groundwater in Arvin-Edison WSD, but only $ 17.11 per acre-foot in the Lower Tule River Irrigation District, and $ 14.00 per acre-foot in the Kings County Water District.[91] Average surface water prices are $30.85 per acre-foot in the Arvin-Edison WSD, $7.50 in the Lower Tule River Irrigation District, and $8.30 in the Kings County Water District The price differentials between groundwater and surface water are $42.65, $9.61, and $5.70 per acre-foot, respectively. Surface water prices tend to be higher where groundwater costs are high, tut nevertheless, the cost of surface water is generally below the cost of groundwater to Valley farmers.

The wide variances in surface water prices, groundwater prices, and the differential between groundwater costs and surface water prices all add to the problems of instituting efficient groundwater management in the Valley. In the next section are examples of pricing policies of various water supply agencies found throughout the valley. They illustrate the interconnection between groundwater costs and surface water pricing. These differences in surface water pricing policies are an additional constraint to the realization of efficient groundwater management in the San Joaquin Valley. In that rent-seeking behavior guides individuals to increase additional supplies of the cheaper cost water, efforts by water users in the San Joaquin Valley will move towards increasing surface water imports and not toward

[90] Despite the wide range in prices, the relationship between surface water prices as a percent of groundwater prices is relatively constant - 49.7% in the Arvin-Edison WSD, 43.828 in the Lower Tule River Irrigation District, and 59.3% in the King County Water District.

[91] Andrews and Fairfax, p. 227.

groundwater management. Since groundwater is the more expensive of the two alternative sources of water, no rent is earned by its use, so no motivation exists for its conservation.

III. B. Pricing in the San Joaquin Valley—Local Water Districts

Water delivery in the five major irrigation districts in the northern portion of the Valley has already been discussed. These districts stretch across three major rivers, have abundant surface water and groundwater supplies, and the Turlock and Modesto irrigation Districts subsidize their water prices by the revenue generated from the sale of electric power. These two districts are the only ones that have their own electricity generating ability, and show that the subsidy from electric power sales can be quite substantial.

The Turlock and Modesto Irrigation Districts built the Don Pedro Dam in the early 1920's. The Modesto Irrigation District today supplies 300,000 acre-feet of water each year to more than 65,000 acres of prime agricultural land, and it services the electrical needs of 60,000 customers.[92] Cheap surface water prices, the price per acre-foot are $0.96 and $0.63 in Turlock and Modesto irrigation Districts respectively, encourage surface water use with little or no incentive to use groundwater. In fact, this area has too much groundwater and in the late 1920's installed drainage wells on the west side of the Modesto district to relieve high water table problems which had prevented the growing of deeper-rooted , higher valued crops.[93] The neighboring Oakdale and Merced irrigation districts, delivering approximately the same quantity of water, charges $6.90 and $9.25 per acre-foot, respectively. One result of such low surface water prices is that in counties in which these irrigation districts lie, 43% of all irrigated acreage is in irrigated pasture and alfalfa hay, as opposed to 16% for the

[92] Charles D. Hobbs, The Water Districts of California, Sacramento: Association of California Water Agencies, 1979, p. 31.

[93] Ibid, p. 32.

rest of the San Joaquin Valley.[94] Pasture and alfalfa hay are relatively low valued crops but are profitable to grow in this area because of the low water prices.

The local, independent private and public water districts, with the exception of the extraordinary circumstances of the Modesto and Turlock Irrigation Districts, generally set water prices to cover the average variable cost of water to the district, while fixed costs are covered by property taxes.[95] There is a high correlation between most water districts' revenues from water sales and their variable costs (made up of administrative, operation, and maintenance costs).[96] Surface water prices generally will be higher in dry years and lower in wet years so that district revenues cover the costs of water delivery. This method of setting prices not according to the marginal cost of water but according to the long-run average cost of delivered water is generally inefficient if long-run marginal costs are greater than average variable costs.[97] Nevertheless, the pricing of water at its average variable cost is widely practiced throughout the Valley.

III. C. Water Pricing Policy of the U. S. Bureau of Reclamation

Two types of districts are affected by the Central Valley project and the water contracts of the U.S. Bureau of Reclamation. First are those which existed before the entry of the Bureau into the Valley, and which must blend water from local sources (both groundwater

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[94] See Highstreet, Nuckton, and Horner.

[95] Bain, Caves, and Margolis, p. 319.

[96] Michael Brewer, "Water Pricing and Allocation with Particular Reference to California Irrigation Districts," Mimeographed Report No. 235, Berkeley: California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, 1960.

[97] For an analysis of the efficiency aspects of average cost pricing, see Jack Hirshleifer, James C. De Haven and Jerome W. Milliman. Water Supply, Chicago: University of Chicago Press, 1960, pp. 43-47 and 88-93; and W. D. Morgan, "Allocating the Elixer of Life: Water," in Economic Analysis of Pressing Social Problems, edited by Llad Phillips and Harold L. Votey, Jr., Chicago: Rand McNally College Publishing Co., 1977, p. 158-190.

and local surface water) with water from the CVP. Second are those that formed solely for the purpose of contracting for water from the Bureau. The Bureau did not attempt to disrupt the policies of the former types of water districts nor to change the water allocation arrangements which were already in place. Instead, it treated all districts alike in subjecting them to long term contracts which had the promise of subsidized water prices, acreage limitations, and a restriction against use of Bureau water for urban purposes.

Long term contracts for subsidized water affect subsequent investment decisions by farmers. Since Bureau contracts generally call for the water district members to repay the costs of irrigation-related capital facilities, the financial resources of the water districts are locked-in to this one purpose by California's water district law. The Bureau's contract represents an exchange which involves "relationship-specific" capital, and subsequent exchanges of water (even at prices higher than the Bureau charges) are discouraged.[98] The Bureau's pricing policy has precluded the development of continuous markets in water which could have minimized the total cost of water to the San Joaquin Valley." Because of the rigidity inherent in the surface water pricing policy of the Bureau, the relationship between surface water use and groundwater use becomes imbalanced because capital investment in alternative forms of water supply, such as groundwater-basin protection (either in the form of conjunctive use or efforts to eliminate common property behavior), are precluded.

The Bureau has contracts for two types of water: Class I water which is "firm" water, and Class 11 water which is available only during wet years in which a surplus of water above Class I contracts exists. Class II water was designed to replenish groundwater basins, but it is generally used to grow additional crops. The available Class I water is not sufficient to meet

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98 See Paul L. Joskow, "Contract Duration and Relationship-Specific Investments," The American Economic Review 77, 1,(Mar. 1987), p. 168.

99 Bain, Caves, and Margolis, p. 229.

the demands of all irrigators in the CVP service area. But at the time of contracting in the early 1940's and 1950's, irrigated acreage was expected by the Bureau to remain unchanged because the Bureau's water was to be used only on existing farmland. However, irrigation investment decisions made by Valley farmers were based on the expectation of continued subsidized surface water prices and the prevailing groundwater costs. In relation to today's groundwater costs, these investment decisions (due to subsidized water prices) resulted in too much land under irrigation. Farmers, once irrigation investments become sunk costs, become willing to incur very high groundwater costs since total water costs are lessened by the subsidy on their surface water use.[100] Thus, the subsidized surface water prices of the Bureau and their use of long-term contracts can be seen to contribute to the groundwater overdraft problem in the Valley.[101]

The Bureau attempted to address local groundwater conditions. First, it used a "safe yield" calculation as a basis for allocating water supplies among districts.[102] The Bureau estimated the amount of water which could be pumped from the groundwater basin without involving long-term overdraft, and then allowed districts to contract for an amount of federal water which would meet the "residual" demand. Though Bureau water may have temporarily eliminated overdraft in some areas, without the ability to restrict an expansion in irrigated acreage, overdraft eventually returned. The Bureau's other groundwater 'program' centered on the allocation of 'Class II' or nonfirm, surplus water. Because Class 11 supplies are not dependable, contractors pay less for

[100] In terms of the standard "shut down" decision model of microeconomic theory, a firm will stay in business until the marginal revenue falls below the firm's average variable cost. Generally the model is used to explain how falling prices eventually drive firms out of business, but in this case, the marginal revenue of the farms are not affected but their average variable cost curves are pushed up by ever higher groundwater costs.

[101] Subsidized water prices also make the relative price of capital much higher, thus delaying the date at which capital investment in water saving devices such as sprinkler or drip irrigation systems will replace furrow irrigation.

[102] Andrews and Fairfax, p. 255.

them. The Bureau's policy was to encourage contractors to use nonfirm water in planned recharge operations (at least only on the east side of the Valley since west side (San Luis) service contracts are for firm water only). Some of the largest Class II contractors have among the region's worst overdraft problems, while others,[103] such as the Arvin-Edson Water Storage District have succeeded in eliminating overdraft, at least for the present[104] Most Class 11 water was used for the expansion of irrigation and not as part of a planned recharge operation.

When Class II water is used for groundwater recharge or as part of a conjunctive use program, it may alleviate groundwater problems in that the difference between groundwater pumpage and groundwater recharge (the definition of overdraft is that pumping exceeds recharge in a groundwater basin) becomes less. Class II water increases the supply of water to the farmer who uses groundwater, but it does nothing to restrict the demand for groundwater. The cause of overdraft, the common property nature of groundwater use, is not affected by the presence of Class II water, so the problem of over draft remains unsolved. Management of demand as well as augmentation of supply is necessary to efficiently manage the groundwater resources of the Valley.

III. D, Pricing Policies of Water Districts in the Central Valley Project

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103 Apart from its Class II water policy, the Bureau's pricing policies have, at least in one area, been helpful In alleviating certain local overdraft situations. In the Westlands Water District the Bureau had no trouble selling its subsidized, Class I, interest-free federal water to the Westlands pumpers who were facing extremely high groundwater costs. Because of its low priced water, the Central Valley Project did not run into the same water-selling problem as did the State Water Project in Kern County, an area very similar to and immediately south of the Westlands. Because the State Water Project water was often more expensive than groundwater, many farmers continued to pump rather than buy state water. Partly because of favorable federal pricing, the Westlands' farmers gladly substituted CVP water for groundwater, and current overdraft is now negligible.

104 Andrews and Fairfax, p. 256. The intricate surface water exchange program of the Arvin-Edison Water Storage District was discussed in an earlier section of this chapter, but it should be noticed that it was not Class 11 water that has improved the overdraft conditions in the district, but the firm water that was achieved through the exchange program.

Many considerations enter into the pricing policies of the water districts which receive Central Valley Project water. As users' cooperatives, they are primarily interested in maximizing the profits of their members, and this means they desire to charge as low a price as possible for water. However, contractual obligations with the Bureau require that they obtain sufficient revenue to pay for their allotted water. Most districts know ahead of time how much Class I and Class II water will be available to them, and so they set the water prices to their members accordingly.[105] Their prices must not be so low that payments due the Bureau are not covered and they cannot be so high that irrigators prefer to use groundwater.

The general pricing policy of the water districts served by the Central Valley project can be highlighted by reference to the Lower Tule River Irrigation District, located in west central Tulare County.[106] The Lower Tule River Irrigation District has 61,200 acre-feet of Class I water at $3.50 per acre-foot, and up to 238,000 acre-feet of Class 2 water at $ 1.50

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105 Because summer irrigation water in the Central Valley derives primarily from the melting of winter snowfall, districts with access to storage capacity know in advance of the planting season of most annual crops how much water will be available. The districts served by the Bureau of Reclamation's Madera and Friant-Kern canals are largely in this position. The Friant Dam provides an estimated 900,000 acre-feet of firm yield or Class I water at $3.50 per acre-foot, and 400,000 acre-feet of Class II water at $ 1.50 per acre-foot The guaranteed supplies of Class I water can be drawn at any time in the season; the amount of Class II water that is known in advance is somewhat variable in delivery time. These districts require their customers to place orders for water early in the season. In many cases, water tolls and taxes are juggled in ways described above to achieve a rough balancing of demand and supply over the season. Some districts, however, ration by cutting back all orders proportionally when they overestimate the anticipated supplies. In the Fresno Irrigation District, which receives surface water regulated by the Pine Flat Dam, when supplies are short, they cut down on the number of deliveries, or "runs", during the season. Instead of raising the price of surface water during a drought and allowing farmers to make price motivated adjustments, the farmers use what surface water is available and make up the difference by pumping groundwater. The price of groundwater pumping is the marginal cost of water to the farmer, though he does not pay the marginal cost for surface water.

106 This section on the Lower Tule River Irrigation District as well as the following section on the Chowchilla Water District and the Madera Irrigation District are taken from Bain, Caves and Margolis, pp. 335-336. Presently the Lower Tule River Irrigation District receives its water from three sources: the Tule River, the Friant-Kern Canal and the Cross Valley Canal. The average cost of surface water per acre-foot is $7.50. The above prices for Class I and Class 11 water, though in 1960 dollars, are still current today.

an acre-foot. Surface water costs to the district range from $3.50, when only Class I water is available, to $1.91 an acre-foot, if the total allotment of Class II water is available. The District has varied the water price to its members between $3.20 and $2.40 an acre-foot depending upon the supply of surface water available, raising it in dry years and lowering it in wet years. The negative correlation between the quantity of water available and the price of water has achieved two objectives for the District. First, it controls the amount of water demanded by irrigators from the Lower Tule River Irrigation District. The pump lifts for the District's irrigators vary from 60 to 200 feet, so that the out-of-pocket costs of pumping from the shallower wells are within the range of the surface water price.[107] With these prices, many farmers are indifferent between using surface water and groundwater supplies. The demand elasticity for surface water is very high over this range, and small price adjustments strongly affect the quantity demanded. A second desired result of this pricing policy is that it allows the District's revenue (from water sales to irrigators) to vary with its total costs (from purchase of water under contract with the Bureau) between dry and wet

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[107] Energy costs in the early 1960's were four cents per acre-foot of lift, so the variable cost of groundwater was approximately between $2.40 and $8.00 per acre-foot. Presently, the variable cost of groundwater is $22.60 per acre-foot because of rising energy costs, Surface water prices have not increased as rapidly.

years. Thus, changes in the District's financial obligation to the Bureau can be met without changes in assessments or wide variations in the District's surplus.[108]

According to Bain, Caves, and Margolis:[109]

> Practices of the Lower Tule River District are typical of those of many irrigation districts. The adjustment of water tolls to affect farmers' incentives for choosing between surface and pumped ground water is common throughout the important districts on the east side of the San Joaquin Valley, There are at least three reasons for this. First, the pump lifts for irrigators in much of this area are such that the average variable (and marginal) cost of securing ground water is in the same neighborhood as the average total unit cost to public districts of providing surface water. Second, nearly all irrigated farms in the area retain their own pumping plants and wells, either because the receipt of surface water is relatively recent or because surface supplies have never been sufficient to last through the whole irrigation season. Third, the requirement of the Bureau of Reclamation that its contract customers pay for their total contractual supplies (after a development period), whether they take them or not, compels the districts to develop pricing methods which induce farmers to use surface water when available and thus accomplish cyclical storage of water in the underground aquifer.

A second example of within district pricing policies is provided by the Madera Irrigation District and the Chowchilla Water District. Both districts are located between the Chowchilla River to the north and the San Joaquin River to the south, and are served by the Madera Canal. Each district has very favorable groundwater conditions, and their surface water pricing policies take this into account. As in the case of most Friant-Kern Canal water

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[108] Based on an interview Bain, Caves, and Margolis had with William A. Alexander, the engineer and manager of the Lower Tule River Irrigation District, August 26, 1960, in 1958, a year when irrigation water was particularly abundant, the Lower Tule River District resorted to shifting from a surface water price per acre-foot to a charge per irrigated acre. This maneuver reduced the marginal cost of surface water for the irrigators to zero, except for their own labor it caused a considerably greater quantity of water to be applied, as two crops that are widely grown in the District, alfalfa and permanent pasture, yield outputs that are quite responsive to the amount of water applied. From the District's point of view, this policy also had the desirable results both of causing considerable surface water to percolate through to the underground basin and of encouraging the growth of pasture grasses which loosen the soil and increase its permeability for further percolation. The benefit of lower future groundwater costs was captured by encouraging irrigators to use as much water as possible, by the decrease in the marginal cost of surface water.

[109] Bain, Caves, and Margolis, p. 336. Also see Brewer, p. 94.

districts, they set surface water prices according to the average cost of groundwater pumping in the district. In the Chowchilla District, surface water serves only about 60 percent of the District's lands; the remaining land depends on groundwater pumping at all times. Likewise, In the Madera Irrigation District the surface distribution system was not extended to serve all farms. In addition to the necessity for setting water prices low enough to induce farmers within reach of the surface distribution canals to use them (groundwater is within reach at shallow depths for all farmers in the district), there is the problem of "equitable" treatment of district farmers who cannot use the district's surface water but who nonetheless are assessed property taxes to pay for the water. By keeping surface water prices low, more water is used by those who have access to it and more water percolates into the underground basin, where it is then made available to those who rely solely on groundwater pumping. According to an engineer with the Chowchilla Water District, under such a pricing policy the farmer who operates his own pumps "lays out" about as much as one who depends on the District's supply, and no inequities are felt.[110]

The delivery of surface water to only part of the lands of a district is a common characteristic of the delivery systems of water districts in the Valley. In addition to the above two districts, it is also adopted by the Arvin-Edison Water Storage District, the Consolidated Irrigation District, Lemoore Canal and Irrigation Company, the North Kern Water Storage District, and the Fresno Irrigation District, among others. It is, furthermore, practiced in

[110] See Bain, Caves and Margolis, p. 336 who attribute this opinion to Francis C. Adair, resident engineer, Chowchilla Water District, who they interviewed on August 17,1960.

districts which have excess land holdings[11] - -- since only limited acreage can obtain surface water. The excess acreage is irrigated with groundwater, which includes water applied to the non-excess land but which percolates to the wells on the excess land.

The pricing policy of these districts has complicated a major concern for "equity" between those who are members of the same water district but obtain water from different sources.[112] The early policy of setting surface water tolls to equal groundwater costs was designed to provide some equality in the total water costs across farmers. However, as groundwater costs rose, but surface water prices remained the same, property taxes were varied so that tax-inclusive water costs were equated. In the Fresno Irrigation District a uniform tax rate is used for all land, but the value of land without surface water service is placed at a lower assessed value. In 1927, when this procedure was first introduced, land relying exclusively on groundwater was assessed at 60 percent of land with surface water delivery, but the assessment has subsequently been lowered to 40 percent because of increased cost of pumping as the groundwater table receded.[113]

Equity cannot be overlooked as an internal pricing policy in most if not all of the water districts in the Valley. Within any one district it is unlikely that soil and other growing

111 By identifying those farmers eligible to receive federally subsidized project water, the acreage limitation affects price differentials between surface water and groundwater across the Valley. When contracts were made, those districts such as the Fresno Irrigation District and others upstream on the Kings River which were characterized by small farms, would be granted a larger water allocation when measured in acre-feet per acre across the whole of the district. Those districts with large excess land holdings would be given only sufficient water to supply lands that met the acreage limitation. Whether or not the excess lands were sold, these districts would receive a smaller quota in terms of acre-feet per acre. Thus, more land would need to rely upon groundwater and, thus, overdraft would be worsened by the acreage limitation provision of federal water supply.

112 For a discussion of the issue of equity in water districts see Maass and Anderson.

113 Maass and Anderson, p. 176. Also explained here is that lands which must pump water from the canal of the district to a higher elevation have their lands assessed at a lower value than lands which receive water by gravity flow. This is in contrast to the pricing policy of districts mentioned later which charge higher elevation farmers a greater price per acre-foot of delivered water.

conditions will vary greatly. When farmers organize to secure surface water supplies, agreements must be made to distribute that water in some manner. Formation of a water district requires the bearing of financial responsibility, a responsibility that must also be spread among the members of the district. This responsibility is spread in terms of water prices and also property taxes. Equitable treatment of water district members in terms of the sharing of financial responsibility cannot be achieved without the equal sharing of water delivery costs, though equal sharing of surface water supplies is not necessary.

As opposed to equity considerations which lead districts to minimize the variation in water costs among similarly situated members, other factors may enter into the pricing structures of water districts. Other considerations, such as differences in land quality or elevation, will cause a districts' water prices to vary according to the circumstances of its water users. The James Irrigation District receives its water from both the Kings River and the Mendota Pool, whereas the Tranquility Irrigation District receives its surface water only from the Mendota Pool. Both districts charge the lowest prices to rice farmers because all the soils of the districts are very alkaline. Not only is rice an alkali tolerant crop, but because it uses large amounts of water, the alkaline land is reclaimed as the alkali is leached from the soil. The districts encourage leaching of the soil by charging the rice farmers a lower price for water than is charged to other farmers.

The Orange Cove Irrigation District, bisected by the Fr1ant-Kern Canal, charges its members a different water price depending upon whether they are located east and downhill from the Friant-Kern Canal or west and uphill from the canal. Those east of the canal are charged $5.00 per acre-foot and those west of the canal are charged $20.90 per acre-foot, the difference being the energy cost to lift the water to these farmers.[114] Differences in water prices in this case reflect different costs of delivery to its users.

The above examples notwithstanding, efficiency (i.e. the use of marginal cost pricing) is not a major concern of water districts' pricing policy. The early practice of pricing surface water equal to the cost of groundwater was efficient at the time because, since the only alternative to using surface water is groundwater, the groundwater costs represent the cost of the additional (or marginal) water. But since surface water prices have not risen along with the cost of groundwater (i.e. because of their rigidity), the old surface water prices cannot be considered efficient. The purpose of most districts' pricing policy is the setting of prices sufficiently high to cover all charges by the Bureau. But because the price charged by the Bureau to water districts is a subsidized price, it does not reflect the true opportunity cost of the water.[113]

Surface water costs charged by the Bureau are grossly understated. Assuming full payment of construction, operation and management, and power costs, King and LeVeen estimate that"... the unsubsidized rates per acre-foot would be as follows: Friant-Kern Canal users, $ 17.00; Delta-Mendota Canal users, $27.00; San Luis Canal (Westlands), $53.00; New Melones users, $70.00. In contrast, current rates, for all these users but Westlands, are only $3.50 per acre-foot; Westlands' current rate is $9.30 per acre-foot. Thus, the

[114] The South San Joaquin Municipal Utility District and the Terra Bella Irrigation District, both who are serviced from the Friant-Kern Canal, also employ a two-part pricing scheme depending upon whether or not water must be lifted to reach a farmer.

[115] In addition to problems of scale of the CVP, the failure to include price-adjusted depreciation on fully amortized facilities and the failure to include a charge for the marginal net opportunity cost of the water itself are two other factors that contribute to the contention that the price the Bureau charges for water is too low. The first factor is an accounting bias that treats capital resources as a free good. The second factor is due to the undervaluing of the non-irrigation uses of water, such as recreation, fish and wildlife habitat, and other "multiple-use" features of water. The net effect of these factors is to understate the total cost of water which provides the basis for calculating both the water charges and property taxes collected by the typical district.

difference between current rates and the unsubsidized cost ranges from $ 13.50 to $66.50 per acre-foot."[116]

Because the Bureau's Class I water is undervalued, so too is Class II water underpriced. The price of Class II water has a relatively mechanical relation to the price of Class I water. The theory of the relation between the two classes was that Class II generally would be available only before the irrigation season, and used for "pre irrigation", meaning that districts could use it only by first sinking it into the underground basin for their irrigators to pump up during the irrigation season. To encourage water users to use Class II water for underground storage and Class I water for direct irrigation, the difference in the price between the two classes was set equal to the average cost of pumping water from underground storage. The $2 difference ($3.50 for Class I vs $ 1.50 for Class II) between the two classes was set, in general, to do just this.[117] As overdraft caused an increase in groundwater costs, the relationship between the two classes of water was distorted by the continuation of this $2 price differential. No longer would irrigators have an incentive to percolate Class II water underground for use at a later time if the average cost of extraction was greater than two dollars, but the incentive would be to use the Class II water for surface irrigation when it became available.

Due to the need to dispose of all water it imported into the Valley, and the bureaucratic desire to maximize territorial influence, the Bureau set water prices in the original 40-year

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116 KingandleYeen.p. 20.

117 Bain, Caves, and Margolis, p. 470. According to the authors, this pricing philosophy was explained in U.S. Dept of Interior, Bureau of Reclamation, Region 2, Factual Report. Lindmore Irrigation District, 1948.

contracts too low.[118] The low price encouraged over-extension of irrigated lands, and led to excessive total (surface water and groundwater) water use when compared to a price that would have equalled the true social marginal cost of water. The legacy of subsidizing surface water prices is an inefficient allocation of both surface water and groundwater. The consequences for groundwater are that the lower the price of surface water, the greater the acreage of irrigated cropland and the greater the amount of groundwater overdraft. Also, given the opportunity to receive subsidized water, many districts formed quickly and they applied for more surface water than the Bureau had to supply.[119] Once the price signal to irrigators was distorted, the farmers of the region overinvested in irrigation facilities by bringing too much land under irrigation, which subsequently led to groundwater overdraft.

The effect the CVP had on groundwater overdraft in the San Joaquin Valley is described by one author as follows:[120]

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[118] Though the U. S. Bureau of Reclamation claims the benefits from the CVP outweigh the costs, it is the contention of many authors that the benefit-cost ratio for the Central Valley Project is below one, meaning the costs outweighed the benefits. See Bain, Caves, and Margolis, Appendix C, pp. 695-718 and Chapter 15, pp. 529-576 for a most detailed account of the efficiency of the Central Valley Project. In the authors' words,"... we have found the 'basic features' of the Central Valley Project and its separable components to represent an uneconomic use of resources at their present scales. Either they should not have been built at all, or they should have been constructed to smaller scales." (p. 561). Furthermore, Table 29, p. 558 shows that no feature of the Central Valley Project has a positive benefit cost ratio at an interest rate of 5% or higher. Also see David L. Shapiro, "Statistical Appraisal of the Economic Efficiency of the Trinity River Diversion of the Central Valley Project," Ph. D. dissertation, University of California, Berkeley, 1966; and Joe S. Bain, "Water Resource Development in California: The Comparative Efficiency of Local, State, and Federal Agencies," in Water Resources Management and Public Policy, edited by Thomas H. Campbell and Roberto. Sylvester, Seattle: University of Washington Press, 1968.

[119] According to a statement by Mr. David Stoner, the Assistant Head of the Branch Operations and Plans for the Bureau, working on the Central Valley Project, "We have a shortage of first-class, firm water and we believe that we should distribute that water where it is needed the most and in almost every case the district applications have been for more water than we think they should have." U. S. Congress, Senate Committee on Public Lands, Exemption of Certain Projects from Land-Limitation Provisions of Federal Reclamation Laws, 80 Congress, 1 session, Washington: U.S.G.P.O., 1947, p.634.

[120] Reisner, p. 353-4. Italics are in the original.

> . The Central Valley Project was, in fact, to have an interesting -- a startling -- effect on the groundwater table of the San Joaquin Valley. In Tulare County, at one test well, the aquifer dropped sixty feet between 1920 and 1960, the year the first CVP water arrived. Thanks to the flood of new surface water, the water table then rose twenty feet in nine years. Just three years later, however, it had dropped another thirty-three feet. In Kern County, where the depth to groundwater is much greater, farmers who had pumped from 275 feet during World War II were pumping from 460 feet by 1965. The reason was obvious: the CVP and the Corps of Engineers projects on the Kings, the Kaweah, the Tule, and the Kern had delivered a lot of surface water throughout the valley, but they had encouraged so much agricultural expansion that they hadn't really relieved the pressure on the aquifer at all. For a while things were better; then the project actually made things worse. Half the agricultural water used in the state was still coming out of the ground -- even farmers who got cheap federal water continued to pump from their own wells in order to irrigate as much land as possible -- and with three times as much irrigated land in production as there had been thirty years before, the big projects... were just encouraging more pumping.

The interaction between surface water prices and groundwater prices creates a symbiotic system, Surface water prices are based on groundwater prices, but groundwater costs are influenced by the level of surface water costs, etc. One price cannot be changed without influencing the other. Instituting efficient groundwater management will require a change in the price relationship between groundwater and surface water. If surface water price and hence surface water use are not efficient, then the imposition of an efficient groundwater management will not result in efficiency of total water use. An inefficiency anywhere in an interconnected system will make the whole system inefficient.

Rigidities in the Bureau's pricing policy -- the use of long-term contracts and subsidized prices -- will make changes in groundwater management more difficult to achieve. The economic incentive for instituting efficient groundwater management is that an improvement in social welfare will follow, But this improvement may not be forthcoming if surface water inefficiencies persist, Furthermore, changes in the prices of either groundwater or surface water to their true social cost will entail an increase in total water costs to irrigators. In the short run, this means the profits of farmers will decrease until they have sufficient time to adjust to the new water prices.[121] The trade-off of present profits for future profits due to the instituting of efficient groundwater management may not be worthwhile for many farmers, thus giving them an incentive to fight against any groundwater management plan.

HI. E. Water Districts on the West Side of the San Joaquin Valley

III. E. 1. The Westlands Water District

The Westlands Water District, which receives its water from the San Luis Reservoir of the Central Valley Project, and the Kern County Water Agency, which receives its water from the California Aqueduct of the State Water Project, are the major water districts on the west side of the San Joaquin Valley. Because only two water districts dominate the area's surface water use, the west side has a less complicated story with respect to the pricing of surface water than the east side, but the results with respect to groundwater overdraft are generally the same. Groundwater overdraft encouraged irrigators to call upon the federal or state government to import expensive, additional surface water supplies. Because water trading was not allowed, the rigidity of water allocation caused imports of surface water to be a more expensive source of water than otherwise need be under alternative institutional arrangements. Water, once delivered, often ended up in the hands of large landowners who were greatly subsidized or enriched at the cost of taxpayers. Furthermore, because groundwater pumping was not controlled, additional surface water led to the expansion of irrigated agriculture and to a continuation of the overdraft which the imported water was supposed to improve.

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121 Such adjustments may require greater investment in capital in order to lower the amount of water used per acre, or may also entail the transfer of land out of irrigation.

CYP water is delivered to irrigators in the Westlands water district for about $ 16.00 per acre-foot. Because groundwater costs are upwards of $80.00 per acre-foot, the cheaper water not only provides a great profit to the water users, but has greatly relieved, at least temporarily, the groundwater overdraft condition in the district. One report places the cost of delivering the water to the Westlands district at $97.00 per acre-foot, so the subsidized price translates into a capital gain of around $500,000 for each farm receiving the average amount of water delivered.[122] Furthermore, since the average annual revenue per acre is $290, and the water subsidy to the Westlands[1] lands is estimated to be $217 per acre per year, 70 percent of the profits per acre are through taxpayer subsidization and not crop production.[123]

in the Westlands Water District there is not one farm of less than 160 acres, the limit above which farmers cannot use federal water. But due to the efforts of the politicians who support the large farmers in this district, the acreage limitation was raised to 960 acres in 1982, and farmers in excess of this amount were given ten years to dispose of their excess holdings.[124] What of future water use in the Westlands Water District? Regardless of whether farms remain at their present average size of from 2000 to 3000 acres, or are carved into 960 acre parcels, the increase in the number of irrigated acres encouraged by the subsidized prices will lead to overdrafting of groundwater.[125]

III. E. 2. The Kern County Water Agency

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[122] Mark Reisner, ibid. ,501-2. Also see Laura B. King, and Philip E. LeVeen, Turning Off the Tao on Federal Water Subsidies. (Volume I: The Central Valley Project: The $3.5 Billion Give-away). San Francisco: Natural Resources Defense Council, August, 1985. King and LeVeen, In an earlier publication, estimated the social cost of water delivered to the Westlands Water District to be $53.00, and since the actual charge was only $9.30, this resulted in a subsidy of $41.70 per acre-foot of water used.

[123] Mark Reisner, p. 502.

[124] ibid.

[125] See earlier discussion for the expected increase in the number of irrigated acres under present conditions of land ownership and water delivery.

Formed in 1961, the Kern County Water Agency was designed to contract with the state for supplies from the State Water Project on behalf of its member districts. It presently receives about two-thirds of all SWP deliveries to the Valley, The Kern County Water Agency covers the whole county, but of the 42 water districts in Kern County only fourteen of them have contracts for SWP water, and thus are members of the Kern County Water Agency. Because there are no acreage limitations imposed upon the landowners who use SWP water, many of the largest farms in the Valley are found in the water districts which belong to the KCWA.

The following explanation by Henry Vaux of the pricing structure used in the Kern County Water Agency shows that there is very little difference between the pricing policy of districts that receive state water and those which receive federal water:[126]

> A critical factor in surface water prices stems from the general concern over groundwater. Except in districts with no groundwater, a primary purpose of developing the surface water in the first place was to relieve pressure on groundwater supplies. It has always been recognized that pricing policies that resulted in higher prices for surface water than for groundwater would tend to defeat the purposes for which the surface water was initially obtained. Accordingly, it is a policy of the districts and of the Kern County Water Agency to keep the price of surface water at or below the price of groundwater.
>
> The solution to this problem is particularly significant in Kern County, where the initial prices of state water when it was introduced into the county were higher than most prevailing groundwater pumping costs. Three principles govern the pricing policies in Kern districts with both groundwater and surface water supplies. First, the price of surface water to growers who use it exclusively is to be no greater than the costs of pumping groundwater in areas within the district where there is no surface water. Second, in areas with both surface and groundwater supplies, the price of surface water is established at levels lower than groundwater costs to induce the use of surface water. Third, in these joint supply areas the price of surface water is set close to groundwater pumping costs so as to encourage users to maintain wells and pumps for use during droughts and dry periods.

in general, the above pricing policy is not inefficient in its design, but because neither groundwater nor surface water are priced at their social marginal cost (because of

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[126] Vaux, p. 86-87.

subsidies), the resulting prices are inefficient. Surface water prices are not as greatly subsidized in the SWP as they are in the CVP. Users of SWP water do not have the capital, operation and management, or power subsidy of CYP water users, and delivery costs of water vary directly with the district's distance (both horizontal and vertical) from the Sacramento Delta as opposed to the postage-stamp pricing policy of the CVP which does not increase the price of its water with the distance of the receiving district from the storage facility.

Surplus water is delivered to the districts without any distribution charges. The cost of transporting water from the Delta to the KCWA accounts for approximately half the cost of delivered firm water. The KCWA determines the charge per acre-foot of total water delivered by multipling the firm-water price times the percent of total water delivered that is firm water and multipling the surplus-water price times the percent of total water delivery which is surplus water. These two products are then added together to determine the price per acre-foot of delivered water.[127] This average-cost pricing policy allows the district to cover its needed revenue, but does not signal to water users the true scarcity price of water. Furthermore, surplus water is presently available only because the Metropolitan Water District and other users south of the Tehachapis Mountains in southern California are not using their full contractual entitlements. Rather than pay the cost of water which they do not now need, these users have allowed this water to be sold in Kern County as surplus water. Once this water is needed in southern California, this source of surplus water will disappear.[128]

[127] For example, suppose that of 900,000 acre-feet of water delivered to the KCWA, one-third of it, or 300,000 acre-feet, was surplus water. If the price of firm water was $50.00 per acre-foot and the cost of surplus water was $25.00 per acre-foot, then water users would be charged $41.67 per acre-foot (i.e. .33x$25 + .66x$50 = $41.67)

128 Vaux.p.83.

Many farmers, as well as the county's major urban center, Bakersfield, opposed the SWP because of its high water prices,[129] Others wanted new surface water, but resisted centralized allocation of supplies through KCWA, preferring direct contractual agreements between the Individual water districts and the state. Nevertheless, the local Interests supported the project because they were in need of water and wanted supplies without the federal acreage limitation. Property taxes for agricultural users of water, and water prices in general, were lessened by the inclusion of Bakersfield in the KCWA. But as in the case of the CVP, although the SWP was designed to reduce overdraft of groundwater in its service area, groundwater use increased because of the expansion of irrigated agriculture.

IV, Conclusion

The water pricing policy of water districts in the San Joaquin Valley is characterized by inefficiency. Long-term contracts which do not allow the price of water to rise to reflect relative scarcity is only one source of inefficiency. Since Bureau prices are subsidized, the difference between the efficient price of water and that actually paid is even greater. Subsidized prices not only caused an increase in the total amount of water applied on farms, but an expansion of irrigated agriculture. Both of these factors further resulted in an increase in the amount of groundwater extraction. Advantages which the efficient pricing of groundwater brings to the overall agricultural water-use situation are lost if surface water is not also priced efficiently. The history of water prices in the Valley provides no examples of surface water price flexibility, and hence no encouragement for the establishment of efficient groundwater management.

Subsidized surface water prices have made surface water cheaper than groundwater. Use of the cheaper of the two substitute types of water gives rise to a rent which encourages

[129] Andrews and Fairfax, p. 225.

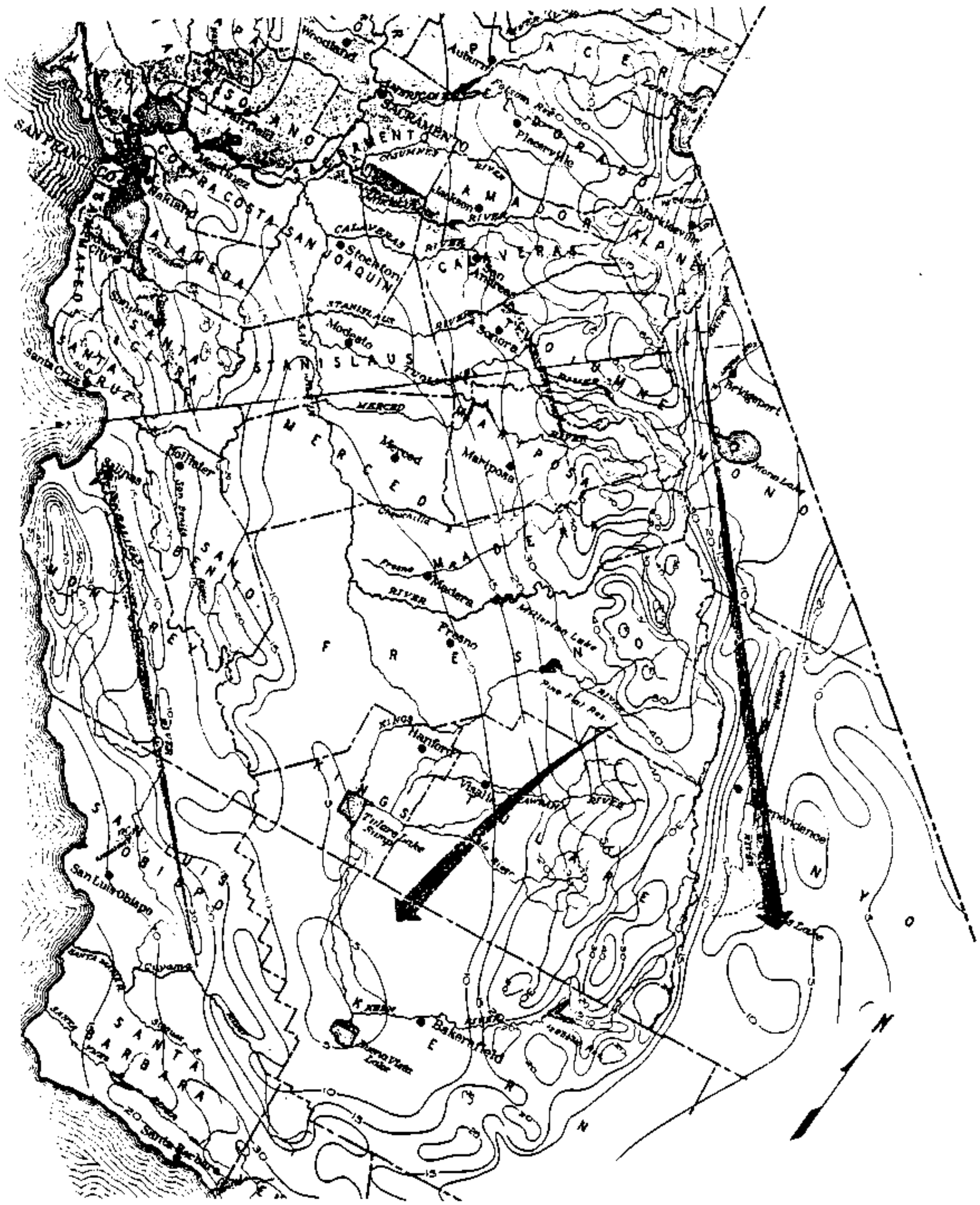
further use of the cheaper water. As explained in the first half of the chapter, the response to groundwater overdraft by farmers In the San Joaquin Valley has been towards increasing the availability of surface water. This rent-seeking behavior will continue to dominate water politics in the San Joaquin Valley as long as the price differential between surface water and groundwater remains. Only if additional surface water is made available at its marginal cost, and if the marginal cost is greater than the cost of groundwater extraction, will water users' rent-seeking behavior be turned towards efficient management of groundwater.

In terms of Ricardian rent theory, as higher priced units of a resource are brought into production, the cheaper priced units earn a rent, or surplus return. The rent is determined and created by the price differential between the two units of the resources. Because surface water's price is subsidized and less than the price of groundwater, rent accrues to users of surface water in the San Joaquin Valley.

Rent-seeking is a behavior motivated by the opportunity to increase rent that accrues from the use of a cheaper priced resource. It has been shown that the pricing policy of water districts subsidizes surface water prices below groundwater prices, which means that the opportunity to increase rent lies with those water users who can increase their usage of surface water. Surface water augmentation has been the policy response of the valley's water districts to the problem of groundwater overdraft. This response is because of rent-seeking behavior by the water users in the Valley.

Though the previous chapter showed that substantial increases in income can be earned by groundwater users from the establishment of efficient groundwater management (e.g. the adjudication of groundwater rights), it is the form in which that income acrues that is of equal importance to the size of the increase. Efficient management will increase income, but that income will be a return to capital, or an interest payment for the maintenance of an agricultural asset (i.e. a higher groundwater table). The payment of higher groundwater extraction costs are delayed by efficient groundwater management when groundwater is the most expensive of alternative sources of water. Delaying this cost increases the income that accures from the use of groundwater (i.e. the value of the asset). If groundwater were the cheaper of two alternative sources of water, the payment of higher groundwater costs may be avoided altogether, not just delayed, by the efficient use of groundwater. In the latter situation, a rent is earned if groundwater is efficiently used, but in the former situation, no rent is earned. The difference between groundwater management producing a rent income as opposed to an interest income is the difference between groundwater being the object of rent-seeking behavior and surface water being the object. It is the opportunity to accrue a surplus that motivates behavior, a characteristic which groundwater lacks in the San Joaquin Valley.

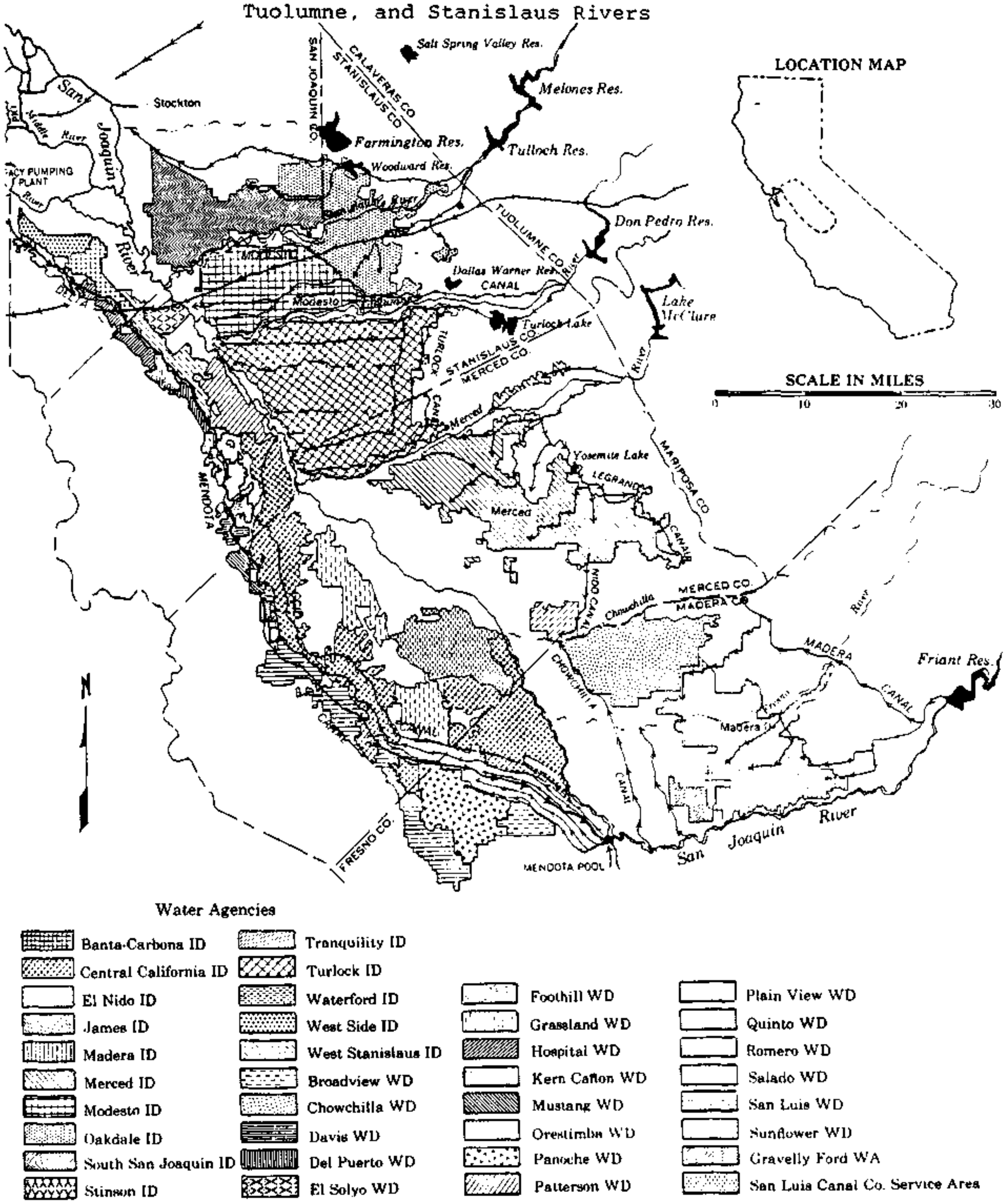
Figure 5-1
Major Rivers, Direction of Flow Arrows, and Precipitation Contours in the San Joaquin Valley



Source: Calif. Dept. of Water Resources, Bulletin 3

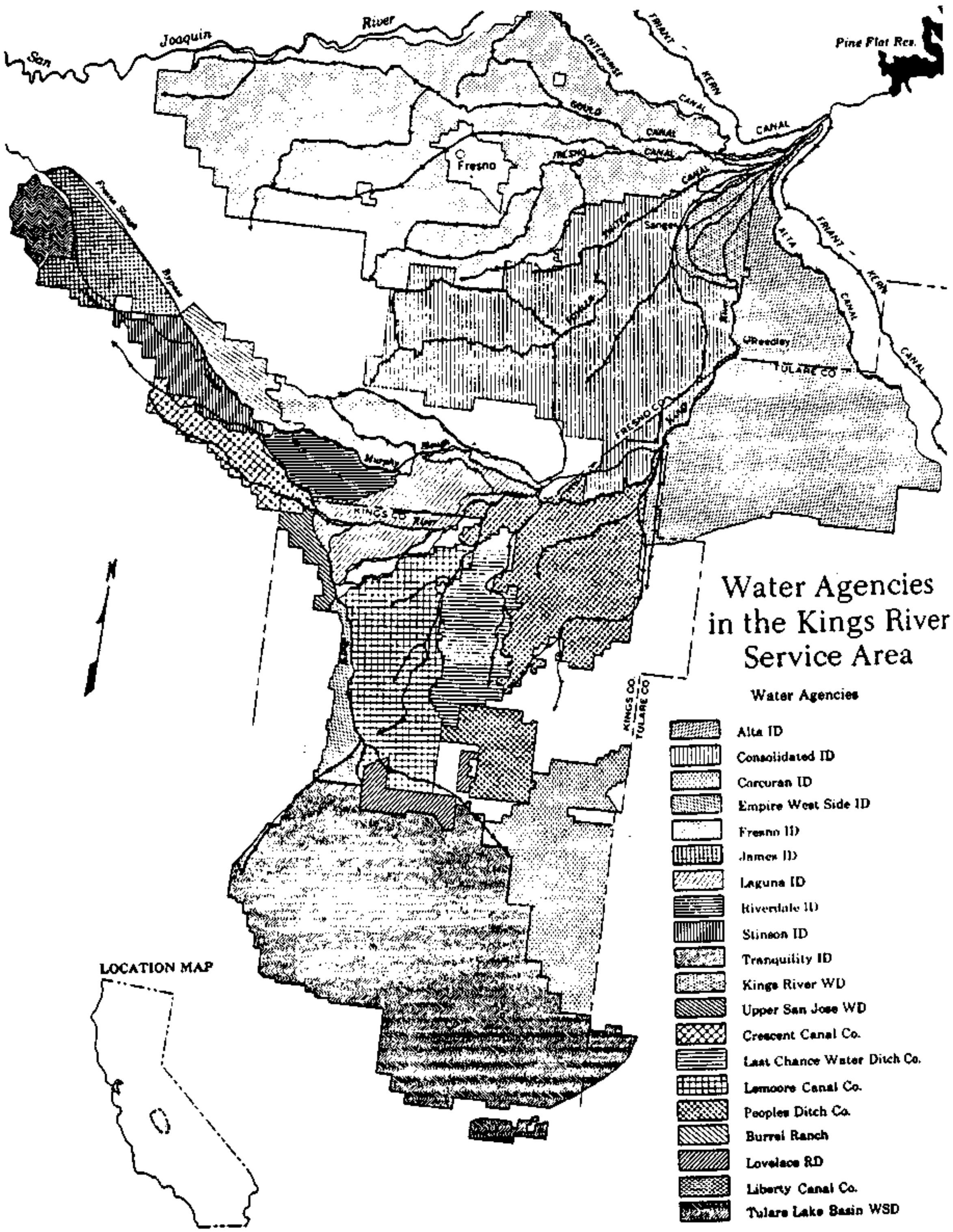
Figure 5-2

Water Agencies Along the Merced, Tuolumne, and Stanislaus Rivers



Source: Bain, Caves, and Margolis

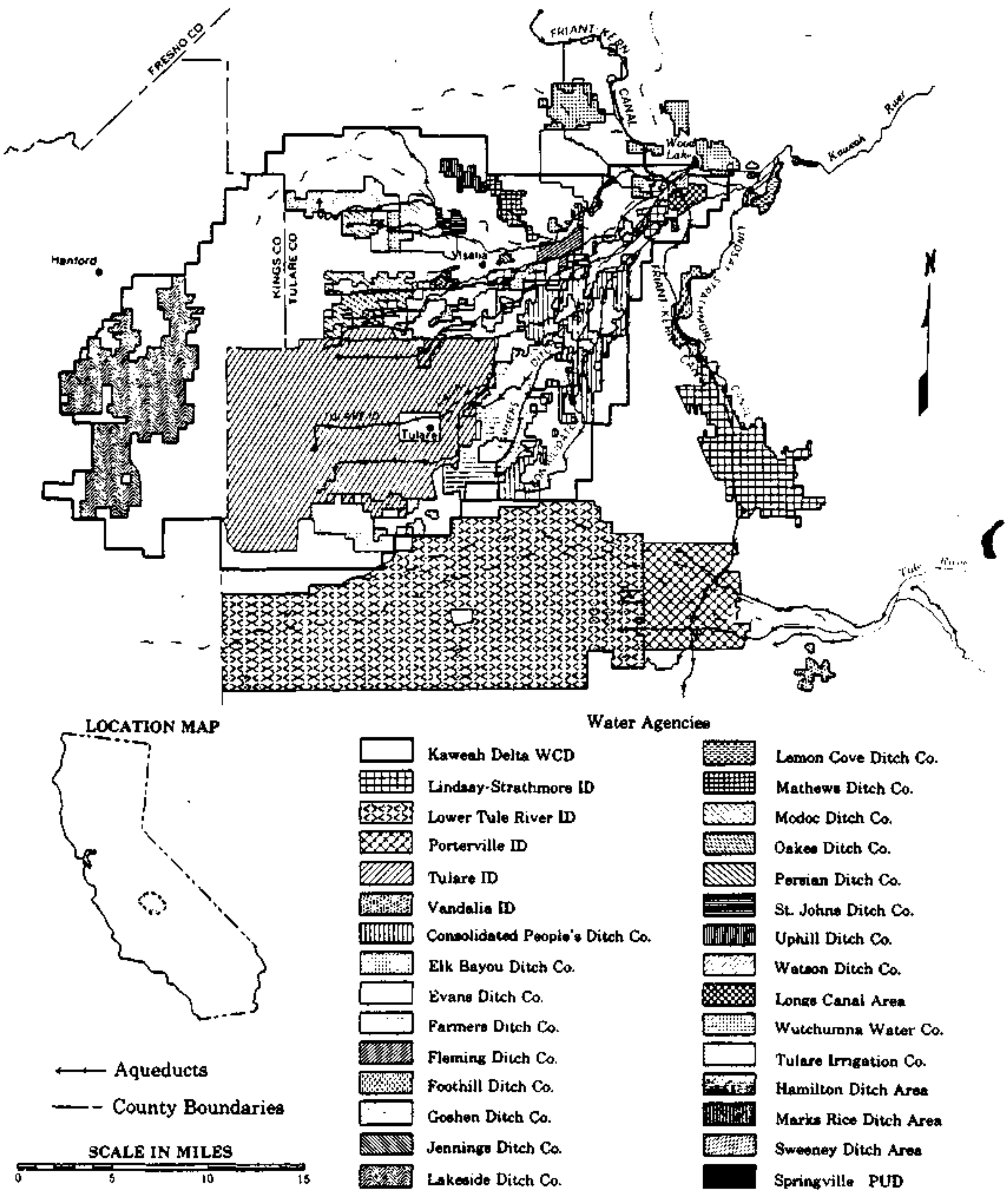
Figure 5-3



Source: Bain, Caves, and Margolis

Figure 5-4

Water Agencies Along the Kaweah River



Source: Bain, Caves, and Margolis

CHAPTER SIX

INITIATING PROGRESS TOWARD EFFICIENT GROUNDWATER MANAGEMENT

I. Introduction

Common property rights allow, and even force, individuals to make groundwater use decisions independent of the use decisions made by others, and independent of any detrimental effect such common property extraction has on the height of the groundwater table. The costs and benefits which any individual user receives from using groundwater is affected by the actions of others who extract groundwater from the same aquifer. Efficient use decisions can only be made communally or jointly by all users taking into consideration the economic interdependency among the many users of groundwater. Groundwater use decisions made by individuals independent of the use decisions of others will misallocate groundwater towards too much extraction too soon, Inefficient groundwater use caused by common property rights results in a lowering of the groundwater table, and an increase in the costs of extracting groundwater.

Groundwater use under common property rights dissipate any increased profits that would otherwise accrue to all groundwater users from efforts to raise the groundwater table. A raised groundwater table is an economic good supplied when groundwater is efficiently extracted from the aquifer. The quantity supplied of an economic good depends upon the reward or price received by the supplier. Common property rights do not motivate behavior which results in a raised groundwater table since the benefits do not accrue exclusively to those whose behavior is responsible for the raised groundwater table. The fugitive nature of groundwater distributes the benefits to others and creates an interdependency of welfare across all groundwater users. Because of this interdependency among those Involved in groundwater extraction, an economic externality exists. The existence of an externality results in resource misallocation, or market failure, if private decisions solely allocate the resource. Correction of market failures call for extra-market solutions, i.e. collective or governmental or political action. Since market failure is herein due to common property rights in groundwater, political action is required to establish an alternative institutional structure that will result in efficient groundwater allocation, thus correcting the market failure.

Common property does not allow the supplier of the raised groundwater table to exclude others from taking its benefits without compensation. Collective action (a change in property rights) which allows exclusion is necessary if the groundwater table is to be maintained at an efficient, or profit maximizing, height.[1] The economic benefits of efficient groundwater management have been presented in an earlier chapter. These benefits, approximately $ 1.29 billion, represent the Incentive to change the existing set of property rights to groundwater - an incentive for collective action. However, there are counteracting incentives which help maintain the status quo (common property rights), and these incentives are constraints to initiating collective action toward efficient management of groundwater.[2]

This chapter focuses on the following political constraints of changing the property rights to groundwater in the San Joaquin Valley: (1) the number of water districts in the

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[1] The existence of property rights that exclude others from usurping the benefits of a raised groundwater table need not result in but may allow the formation of private markets wherein rights to the raised groundwater table are traded among private individuals. Centralized techniques of allocation, such as pumping quotas or pumping taxes, may be used to mimic the efficient resource allocation that would result from a private market. But collective action is nevertheless necessary to affect the change from one set of property rights to another set.

[2] Some of the constraints which make difficult a change in property rights - existing surface water allocation agreements and surface water pricing policies - were presented in the previous chapter. The connection between surface water and groundwater use will continue to be emphasized in what follows.

Valley, (2) differences in the organizational characteristics of those districts, and (3) the lack of consensus among water users on the need for efficient management of existing water supplies. It will be shown that the laws governing water district formation have resulted in a large number of districts being formed in the San Joaquin Valley. The large number of water districts have caused dissipation of the economic benefits, and of the collective incentive to efficiently manage groundwater. Beyond the number of the water districts, the diversity of the districts' physical, economic, and institutional characteristics add to the cost of collective action, to the disincentive to change the existing property rights in groundwater, and to the forces that maintain the existing political equilibrium. As evidence of these constraints, three attempts at legislating groundwater management will be analyzed showing that the failure to adopt these groundwater management policies was due, in part, to the Valley's historical success at procuring additional surface water from surplus-water areas. However, the political techniques which brought this success are not well adapted to advancing the policy of efficient groundwater management, and new techniques must be adopted before groundwater management can be instituted.

II. The Problem of Large Number of Water Districts

II. A. Introduction

The issue of large numbers is very important to the understanding of the problems associated with a common property resource. Individuals have an incentive to use any resource until the increase in benefits from additional usage equals the increase in costs from additional usage. If too many users of a common property resource make individual profit-maximizing decisions while ignoring the effect their decisions have on other users of the resource, then the resource will be overused. Overuse is a consequence of individual decisions which ignore the social cost that results from additional usage. As a result of this overuse, the social or communal profit from use of the resource will be less than If individual resource use decisions took into consideration the externality associated with their private use of the resource. Overuse of the resource is illustrated in the example used by Garret Hardin in "Tragedy of the Commons," where too many cows end up on the common.[3]

The issue of large numbers as a constraint to changing the property rights which govern groundwater extraction is different from the issue of a large number of users (in relation to the size of the resource stock) which contributes to the problem called the tragedy of the commons. The present common property rights to groundwater resources are part of a general political equilibrium. However, the increased economic benefits from efficient groundwater management are an incentive to change the existing property rights structure and to move to a new political equilibrium. Before a new political equilibrium can exist, collective action must be sparked to rearrange the institutional characteristics of the original equilibrium. It is as a constraint to the formation of collective action that large numbers is an important issue below,

The relationship between the numbers of water users and the difficulties of and opportunities for instituting water supply arrangements was introduced in the preceding chapter. The number of competitors for water along the principal rivers in the San Joaquin Valley was shown to vary as widely as the institutional arrangements to supply water. But generally, the larger the number of competitors, the more difficult it was to bargain a water supply arrangement. On the Merced and Tuolumne rivers, the ~~fewness~~ of the number of irrigation districts facilitated the development of jointly operated facilities for water storage and electricity generation. On the Kern River, the ~~fewness~~ of competing users proved

[3] Garrett Hardin, "Tragedy of the Commons," Science 166, 3909, (Nov. 28,1969), pp. 1103-1107. In the tragedy of the commons, Individual users enter the commons if positive profits are accrued from entry (i.e. if average revenue is greater than average cost). However, profit maximizing entry into the commons ceases when total profits are maximized (i.e. when marginal revenue equals marginal cost).

compatible with the negotiation of two water supply agreements, one to allocate the natural water of the river and another to allocate storage space behind the Friant Dam.[4] On the other hand, the numerous and involved interrelations among agencies along the Kaweah River made it impossible for the Lindsay-Strathmore District to effectuate an efficient purchase of either groundwater or surface water rights. Summarizing the importance of the numbers of parties to the probability of reaching water supply agreements, Bain, Caves, and Margolis in their study of northern California's water districts said, "The Kern and San Joaquin cases, taken together with the Merced and Tuolumne cases, suggest that a higher concentration of users along a river can lead to easy agreement, firm rights, and efficient development of storage and distribution facilities,..."[5]

Though the incentive to change property rights may be large, if the group which is to receive these benefits is also large, and if the benefits are evenly distributed across the members of the group, then each Individual in the group will receive only a small portion of the total benefits. This small individual benefit may not prove sufficiently large enough to overcome the costs (i.e. transactions costs) an individual incurs in initiating action which will change property rights. This possibility is increased if the costs disproportionately fall on a small sub-group of Individuals, whereas the benefits are spread among the larger group.

As expressed by Mancur Olson, the connection between collective action and large numbers is that[6]

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[4] Joe Bain, Richard E. Caves, and Julius Margolis, Northern California's Water Industry, Baltimore: Johns Hopkins Press for Resources for the Future, Inc., 1966, p. 430.

[5] Ibid., p. 430. But Bain goes on to say that "...the evidence linking firmly established rights and high concentration of agencies to reallocations of water in the direction of higher productivity Is thin indeed" (p. 431). Agreements on water allocations and even transfers of water do not always result in long run efficient water use if the allocation or transfer is inflexible, or cannot be repeated with changing water prices and demands.

6 Mancur Olson, The Logic of Collective Action, Cambridge, Mass: Harvard University Press, 1965, pp. 2 and 7.

> Indeed, unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational self-interested individuals will not act to achieve their common or group interests. . . . When a number of individuals have a common or collective interest... individual, unorganized action will either not be able to advance that common interest at all, or will not be able to advance that interest adequately.

The "problem of large numbers" Is that given an incentive to act collectively, unless the benefit from such action can be exclusively captured by individual members of a group, no action will be forthcoming. The groundwater users in the San Joaquin Valley, even if it is economically warranted, will not adopt efficient groundwater management because the weight of their numbers provides sufficient inertia to prevent moving away from the existing common property rights to groundwater.

Water districts exist to further the common interests of their members. The height of the groundwater table directly affects the welfare of a district's members. However, any one district is not able to govern the height of the groundwater table, nor thus to adequately advance the common Interest of its groundwater pumpers, because groundwater use decisions of other districts adversely affect the height of the groundwater table. Though all groundwater users and water districts have a common Interest in the coordination of their groundwater use decisions to maintain the groundwater table at an efficient, profit maximizing heigh, because there are so many water districts in the San Joaquin Valley, the costs of such collective action is very high. The high costs of collective action, because of the large number of water districts, is a disincentive to change the existing property rights in groundwater.

According to the California Department of Water Resources, 89 water districts have as their primary responsibility the delivery of surface water to agricultural users overlying the San Joaquin Valley's aquifer.[7] There are 43 California Water Districts, 37 Irrigation

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[7] See Tables 7 and 8 in California Department of Water Resources, "The Hydrologic-Economic Model of the San Joaquin Valley" Bulletin 214. Sacramento: State of California, 1982, pp. 37-39.

Districts, 8 Water Storage Districts, and one Municipal Utility District. In addition, there are many water users who pump groundwater in unincorporated areas not covered by water districts, and there are many water agencies whose water customers are not primarily agricultural users but they deliver water to agricultural users In addition to municipal and Industrial users. The quantitative question of how many is "too many" water districts to prevent collective action is not a question to be answered here, but considering that there is only one aquifer underlying the San Joaquin Valley,[8] 89 water districts appears to be an excessive number of water districts for the efficient management of the groundwater resource. The forces which resulted in such a large number of water districts will be explored below. Among these are the rigidity of surface water rights, barriers on the size of districts and to the expansion of district boundaries, and, finally, the process of district formation in response to the availability of imported surface water supplies.

11. B. Aspects of California's Water Law that Affect the Number of Water Districts

II, B. 1. Water Districts as Collective Action

The conversion of the lands of the San Joaquin Valley from dry farming and ranching to Irrigated agriculture necessarily involved a search for surface supplies, and this almost always entailed some form of communal organization. Interest arose in the construction of projects to deliver surface water because of an Inadequacy, as felt by the Valley's farmers, of existing supplies. Storage dams and diversion canals, too expensive for any one farmer to undertake, led to collective action in the form of water districts to financed the provision of surface water to Valley farmers. Appeal to the legislature by the state's water users for

[8] The Department of Water Resources has divided the Valley into 8 separate basins. Efficient management can be instituted in each of these basins, but coordination across the basins' boundaries will be necessary for the whole aquifer to be efficiently managed. Evidence does exist that large parts of the San Joaquin Valley overlie basins that are fairly well isolated.

assistance 1n building water transfer projects resulted in the passage of acts allowing for the formation of Irrigation Districts, California Water Districts and Water Storage Districts, among others.[9]

California's water district laws established water districts as independent units of government, and provided that they be formed by local initiative under rather loose governing rules. Each district acts on behalf of a limited group of users, and water district autonomy and individuality have been considered major forces motivating the prolific growth of the Valley's local water institutions.[10] Districts reach decisions and act independently from one another and their insularity in planning means that each tends to be a self-supplier of water. The state's policy of encouraging local planning has tended to increase the number of water districts, has ignored economies of scale and other benefits of regional planning, and has discouraged efforts aimed at efficient groundwater management. Cooperation between districts

[9] Three types of independent water districts dominate the water supply picture of the Valley: Irrigation Districts (sections of the California Water Code which refer to the establishment of Irrigation Districts is found in CWC 20500-29978), California Water Districts (California Water District Law at CWC 34000-38999), and Water Storage Districts (Water Storage District Law of 1921, CWC 39000-48401). Irrigation districts are by far the most important type in the region, and exclusively supply irrigation water. California Water Districts and Water Storage Districts also specialize in supplying irrigation water. A fourth type of independent water district found in the Valley, County Water Districts (County Water District Law of 1913, CWC 39000-48401), supply both irrigation and municipal water in significant volume. In addition to these independent water districts, there are major types of local overlay agencies supplying smaller public districts with irrigation water: Water Conservation Districts, County Flood Control and Water Conservation Districts, and County Water Agencies. The first mainly supplies irrigation water, while the others supply water both for irrigation and for domestic and municipal purposes, though with greater emphasis on irrigation water,

[10] Barbara T. Andrews and Sally K. Fairfax, "Groundwater and Intergovernmental Relations in the Southern San Joaquin Valley of California: What are All These Cooks Doing to the Broth?" University of Colorado Law Review 55.2.(Winter 1984), p. 197.

has not been encouraged by the state, yet cooperation is necessary if efficient groundwater management is to be instituted.[11]

As local government units responsible to their members, water districts act on the basis of potential benefits which accrue exclusively to their own members. Districts are not rewarded for decisions based on any broad criterion of economic welfare, so no action has been shown by them. District action to increase available water supply is spurred by internal current or prospective water shortages and is seldom directed toward a project having a scale larger than necessary to serve the needs of the district. As an extension of the state's policy of local planning, water district boundaries were drawn on small and local levels, and projects built to supply water to these small and local districts were of small and local scale. Furthermore, some districts were formed to undertake small projects (particularly those districts whose only purpose was to contract with the federal or state governments to receive and distribute water from either the Central Valley Project or the State Water Project) so in some cases project size determined the size of the water districts.

II. B. 2. Rigidity in Water Rights and Restrictions on Water Transfer as Contributors to the Large Number of Water Districts.

All water districts are cooperative efforts by local farmers to provide themselves with water. Little cooperation across district boundaries exists, or has been necessary, to satisfy a

[11] According to Andrews and Fairfax: "The Valley's collection of adjacent and overlapping local water districts forms a web of semiautonomous institutions which compete for water supply more often than they cooperate to manage it. The local districts make policy in response to widely varying sources of surface and groundwater supplies, soil and land-use characteristics, user demands and coalitions, and political and management attitudes. In general, these variables pose a barrier to direct groundwater control on a district, sub-basin, or basin-wide basis" (p. 157). Similarly, Bain, Caves, and Margolis note that "The existing law of water agencies, moreover, has probably tended to encourage the proliferation of inefficiently small local agencies..." (p. 230), and that the law "favors insularity on the part of the numerous different local agencies" (p. 84).

district's demand for water.[12] Independence is the foremost characteristic of California's water districts, according to Andrews and Fairfax:[15]

> California's constitutional tradition guarantees the districts a substantial degree of independence in their self-governance,... District autonomy and individuality have been major forces motivating the prolific growth of the Valley's local water institutions.... This autonomy and fragmentation have led to overlapping jurisdiction and duplication of services provided throughout the southern San Joaquin Valley,,.. District autonomy, fragmentation, and overlapping jurisdictions both reflect and exacerbate competition among local districts for water supply.... The districts' first concern is their own self-interest in acquiring and exploiting supplies..,,

Competition rather than cooperation characterizes the relationship among districts. Competition for water supplies is verified by California's history of heated rivalry among the Valley's water users. The California Doctrine of water rights, which is a complex combination of riparian rights, appropriation rights, and correlative rights to water, Is a product of the competition for various sources of water at various times in California's history. In general, the fruits of competition were awarded to victorious competitors by the establishment of rigid and inflexible allocations of water rights to final users.

The provision of supplemental surface water is a necessary condition for agricultural development in semi-arid regions such as the San Joaquin Valley. According to B. Delworth Gardner, "During a region's developmental phase, a critical need existed for institutions that would encourage water development and use, not impede them. Prospective users required reliable supplies on a long-term basis. In short, users desired security of tenure in water in order to induce the commitment of other resources required for development."[14] Security of

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12 Valley water users have cooperated in efforts to get the federal governments and the state governments to finance interbasin transfers of water. But local water districts have not been the organizers of such efforts. Most local water districts that purchase water from larger units of government formed only after federal or state provision of water was assured.

13 Andrews and Fairfax, p. 196-7.

14 B. Delworth Gardner, "Institutional Impediments to Efficient Water Allocation," Policy Studies Review 5. 2. (Nov., 1985), p. 353.

tenure results when water institutions reduce the probability that another can involuntarily take one's water. But the same institutions that reduce involuntary transfers of water also increase rigidity of water allocation by prohibiting voluntary transfers between individuals. California water law prohibits voluntary transactions of surface water if the transaction involves a change in point of diversion, a change in place of use, or even a change in type of use if such a change affects the water supply accessible to a third party.[15]

The most common objective of public water districts when considering water supply projects was the satisfaction of demand only within their own territories. However, the diversion, distribution, and delivery of water requires investments in long-lived facilities. Because physical facilities have such a long life-span, to assure their continued use and pay-back capacity, the tie between the water and the land upon which it is used developed a similar long life-span. By assuring a long time-profile over which the benefits of additional water use can be enjoyed,[16] and a long time-horizon over which these benefits could pay for the costs of constructing the capital facilities, rigidity of water rights helped make such

[15] AB 1147, which was enacted in September 1980, has removed some of the restrictions on water transfers. It allows water districts to sell "surplus" water outside their territory for a period of up to five years, instead of three years, before that water is considered abandoned by the district. In 1986 three very important laws allowing for transfer of water rights were also enacted: AB 2746, AB 3427, and AB 3722, AB 3427 extends the period for which water can be transferred to over seven years. For a summary of these and other water transfer legislation see California Department of Water Resources, California Water: Looking to the Future. Bulletin 160-87, Sacramento: Department of Water Resources, 1987, p. 111.

[16] Groundwater law has been unable to eliminate common property access to groundwater which is a source of much uncertainty as to the benefits of storage. Because groundwater law does not allow a district to capture all of the benefits of storing additional water underground, such projects are seldom undertaken. Steps taken to alleviate this uncertainty are AB 1156, passes in 1985, established the Groundwater Recharge Facilities Financing Act which authorized the Department of Water Resources to make grants to local agencies for groundwater recharge facilities; and SB 187 of the same year which confirmed the authority of the Department of Water Resources to build groundwater storage facilities south of the Delta as part of the SWP, and required the Department of Water Resources to contract with local agencies in such programs (e.g. the Kern Water Bank). The most famous court case in regards to water storage in underground reservoirs is Niles Sand and Gravel Co. v. Alameda County Water District. 37 C. 3d 924, (1974).

investments fiscally responsible. Rigidity of water rights was thus a means to encourage the development of irrigated agriculture.

Under California's water law, water rights become rigidly tied to the land once the water supply facilities and water delivery contracts are in place. Rigidity of water rights insulates a district's water supply from the demands of others, regardless of the value of that water to others. This rigidity encourages insularity of behavior and decisions by water districts, and considerably reduces the need to develop water markets or other forms of interaction between districts. Little concert of action becomes necessary, or is even possible, among water users in different water districts or among water districts.

A further rigidity is that water rights held by public water districts are not transferable. Prohibitions on the sale of water outside district boundaries were placed on water districts by the laws governing their formation.[17] Districts hold the water rights of their members in trust, and they execute this trust by administering the local water system on behalf of its members.[18] To dispose of water outside of its boundaries would be to dispose

[17] Restrictions on temporary outside sales are designed to avoid legal complications because of the possibility of developing public service responsibilities outside of the district's boundaries. If an individual receiving water from a district makes capital investment or otherwise becomes dependent upon water delivered by the district, the district accrues a public service responsibility to continue those deliveries. If delivery outside a district is justified because the water is classified as surplus water, and if the delivery continues uninterrupted for a five year period, a district can be assumed to have abandoned the water, and the user of the water to have perfected a right of adverse possession to the water. In either case, a person receiving water outside the district is reaping a benefit without paying the costs of capital facilities to deliver the water, since these costs are generally covered by property taxes.

[18] Andrews and Fairfax, p. 195.

of this trust the districts has towards its members. The water rights held by a district become effectively appurtenant to the district's lands by the exercise of this trust.[19]

The restrictions on temporary sales are not alone responsible for the large number of water districts in the Valley. In conjunction with the restrictions on outside sales are restrictions on expanding the boundaries of a district. Once a district becomes established, and its water rights are rigidly in place, areas outside the district are precluded from access to the water of the established district. To secure supplemental surface water of their own, an outside area must form its own district. As federal and state projects made water available to water deficient areas of the Valley, older and established water districts could not expand into these new areas. Economies of scale in the transport and distribution of water, and economies of scale in the management of surface and groundwater supplies were not taken advantage of because of this inability to expand district boundaries.

California's water laws do not expressly prohibit expansion of district boundaries, but there are nonetheless many factors preventing its occurrence.[20] Any proposed expansion of a district's boundaries requires the adjustment of existing bonded indebtedness so that old and new water users alike share the capital costs of water delivery. Allocation of the costs of new facilities required to service new areas, and the sharing of the costs of older facilities, work against agreements designed to include new areas and to expand district boundaries. When faced

[19] Bain, et. al.,p. 302 suggests that rigidity in the water right laws of California created fears that water supplies must be appropriated at the first hint of rivalry, even if the day of need lies well in the future. Acquisition of surface water well in advance of anticipated needs allowed certain water users to establish rights as against subsequent users. The rigidity of rights once established suggests an incentive to claim an excessive volume of water and an economic advantage windfalling the earliest developers of surface water projects. Late comers to the Valley, with few or no options for supplemental surface water, were left to rely heavily if not exclusively on groundwater for irrigation purposes. Rigidity of water rights can thus be used to explain at least the distribution if not the severity of groundwater overdraft in the Valley's southern and western portions.

[20] Boundaries of districts who purchase water from the Bureau of Reclamation cannot be expanded without the Bureau's permission.

with the issue of debt sharing, any propensity of new areas to figure they can do better in supplying adequate water at low prices would result 1n the formation of a new district rather than inclusion into an existing one.

Another restriction against expansion of district boundaries, similar to the sharing of the bonded debt of existing districts, is the added cost of negotiating fees and other water charges among a diversity of users (a problem of large numbers on a smaller scale). The greater the difference in terms of capital investment, land fertility, or groundwater availability between the incumbent lands and those requesting annexation to a district, the more difficult it is to create an equitable pricing policy for the district as a whole. The costs of any negotiated agreement increases with the variance among the parties to the agreement, particularly if equity is a very important consideration in the pricing policy of the water district.

II. B. 3. The Means of Financing as a Contribution to the Large Number of Water Districts

Because the problems addressed by the earliest water districts were local in nature, so too were the means granted to them, by the state, for solving those problems. California water law did not avail water districts of the financial nor institutional means to build large projects, so the farmers of the San Joaquin Valley created small districts to blanket the Valley's rich agricultural land. Financing of water projects, as specified by California's water law, created the problem of "capital rationing" for the local water districts.[21] A district's borrowing ability was keyed to the size of its initial tax base (rather than to the prospective payoff of any proposed project), and general obligation bonds were the means by which projects were financed (rather than the use of revenue bonds, as was available to electric

[21] Rationing is a means of allocating the available supply of an economic good when a market, an alternative means of allocating based on prices, is not allowed to function.

companies and other competitors of local public water districts for capital to build water storage projects). Use of general obligation bonds was required of local public water districts due to the concern of the lenders with the base payment capacity of the early districts. Concern for the profitability or social benefits associated with the scale of a prospective project was not at issue.

The problem of capital rationing restricted the scale of projects built by any district to a size sufficient only to serve its own lands at the time of district formation. As water shortages became more severe and widespread, and as the demand for irrigation water grew, district land could not be expanded and neither could the size of the water storage project. And though larger projects may have been possible, capital was rationed in small portions to the districts by the above borrowing restrictions. Capital rationing eliminated the opportunity for any district to wholesale water because no district could build a project of sufficient size to become a wholesaler. Furthermore, because local districts had designed projects with a particular output or service area in mind, they never concerned themselves with questions of the optimal scale for any project contemplated, that is if the optimal scale meant a project larger than sufficient to satisfy local needs. Water supply planning in the San Joaquin Valley of California thus had, from its beginning, a local and often small scale focus that forced proliferation of districts to keep pace with the rapid growth of irrigated agriculture.

Capital rationing has produced the present pattern of capital investment in the Valley. The pattern of capital investment in water storage and delivery projects finds the federal government and state government having financed the large interbasin storage and transport facilities, whereas the majority of local public districts have financed only the distribution facilities within their borders. Only the expenses required to build distribution canals between their members' farms and the major canals of state or federal wholesalers of water could be covered within the restrictions of capital rationing, so most water districts did not have to be very large in size to serve their members. Large water supply projects, those which would have required either large water districts or the ability of one district to sell any surplus water outside its area, were rendered unfinanceable because of capital rationing. Even if large projects could have been very successful ventures, California water law limiting the financing of projects to the property value of a district's lands made such opportunities beyond the revenue threshold of local districts. Instead, the federal and the state governments used their larger taxing and spending powers to deliver large quantities of water to the districts of the Valley.

II. B. 4. Federal and State Water Supply Projects as Contributors to the Large Number of Water Districts

Entrance of the federal and state governments into the Valley's water supply landscape did not slow the proliferation of districts in the Valley. The newer districts in the area, those formed on the south and west side in the 1940's and 1950's, were organized under the older general acts.[22] Irrigation Districts, California Water Districts, and County Water Districts, though unable to individually or independently finance large interbasin water transfers, became empowered to purchase water from the federal government's Bureau of Reclamation or the Army Corps of Engineers, or from an overlay agency purveying water purchased from the state's Department of Water Resources. As such, local public water districts became retailers of water, buying water from federal or state wholesalers and selling it to their members. As

[22] As mentioned by Andrews and Fairfax, p. 198, all the "newer" districts in the area were organized under the older general acts. When additional surface water was imported into the Los Angeles area as a solution to groundwater overdraft problems, special districts were formed to actively manage groundwater use. These "modern institutional forms pioneered in south coastal California to integrate surface water and groundwater use never appeared in the Valley." Only the Kern County Water Agency was a special district created with both surface water and groundwater management responsibilities.

more water became available to the Valley, more and more water districts were formed to distribute that water to its member's lands.

The majority of water districts formed in California since the late 1930's were stimulated by a potential major wholesale water supplier - either the federal government's Bureau of Reclamation or the state's Department of Water Resources. Of the thirty-seven Irrigation Districts, California Water Districts, and Municipal Utility Districts holding permanent contracts in 1960 for water service from the Bureau's Contra Costa, Delta-Mendota, Madera, and Friant-Kern canals, only six. were organized before the prospect of federal wholesaling activity.[23] The "extra" 31 water districts were formed to absorb the USBR's supplies, and no consolidation of existing districts nor formation of a few large districts was ever considered.

The role of the federal government in inflating the number of water districts was shown in the previous chapter's discussion on the allocation of supplies from the Friant-Kern Canal. The first districts to organize were those with the most unsatisfactory ground-water conditions The formation of districts to purchase water from the Bureau's Friant-Kern Canal reached an impasse for several years as the Bureau insisted on contractual terms which the districts vigorously opposed. By 1950, however, a period of years of high rainfall was passing and water tables were continuing to drop sharply, thus forcing additional districts to terms with the Bureau. As more districts signed permanent, long-term contracts with the Bureau, areas not under contract began to fear they would be left without access to Bureau water, The realization that the end of this supply was in sight resulted in additional districts forming to fill in the holes between organized areas until the land which could be economically served by the canal was fully covered. Even after the Bureau of Reclamation had entered into

[23] Bain et al., p. 301.

contracts for all of its available supplies, new districts kept forming in the hope that supplementary facilities would be built to serve the area.[24]

In Kern County, partly because of the very large units of land ownership in the region, the limited waters of the Kern River were long allocated without the appearance of any public districts, though other forms of collective agreements among the water users were in force. However, the prospect of large transfers of water to this area by the State Water Project and the San Luis Unit of the Central Valley Project led to rather quick organization of most of the county into a number of large water storage districts.[25] Given the large ownership parcels, in an effort to economize water distribution, the state required all water deliveries from its State Water Project to these lands be handled through the Kern County Water Agency. Even though the KCWA allowed for improved distribution of the state's water, it did not replace any previously existing district, and actually added to the number of districts in the Valley.

II. B. 5. Summary of Aspects of California's Water Law that Affect the Number of Water Districts

In summary, the factors that have led to a proliferation of public water districts in the San Joaquin Valley are the emphasis on local planning, capital rationing, and the conditions under which additional water supplies were made available by the state and federal governments. Local public water districts were formed in response to local problems felt by prospective members rather than to opportunities to advance agricultural development beyond the district's boundaries. Restrictions on the size of local districts for the purpose of local

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[24] See Bain, et al. Chapter 9 on formation and evolution of water agencies, and for a complete discussion of the factors affecting individual water district formation.

[25] In Kern County, the Semitropic, Rosedale-Rio Bravo, and Wheeler Ridge-Maricopa were added to the previously organized Buena Vista, Arvin-Edison, and North Kern. The huge Westlands Water District was formed in western Fresno County.

planning, combined with restrictions on their borrowing abilities, reduced the affordable projects necessary to solve their problems to a small size. Small and local projects only require districts that also of a small size. Once the structure of small districts was in place, It tended to become very rigid given several elements which prevented them from increasing in size. First, once a district had established its distribution system, its chances of attaining scale economies through expansion were very slight. Second, a range of legal and contractual problems tended to make the inclusion or exclusion of territory a rather complicated matter, and where there was a choice, territory outside a district often prefered the home rule gained by forming its own agency rather than joining an existing one.

The state's policy of water resource planning on a local scale encouraged small scale projects, produced many small water districts, and thus a large number of districts were required to supply water to the Valley's farmers. This local and small scale focus, plus the rigidity in the location of district boundaries, forced a proliferation in the number of districts necessary to keep pace with the rapid growth of irrigated agriculture in the San Joaquin Valley. This large number of independently acting water districts has become a substantial barrier to the efficient management of groundwater in the Valley. Water districts have no tradition of coordinated effort in managing water supplies, but such coordinated management is required for efficient groundwater management. Furthermore, the large number of water districts disperses any economic incentive to efficiently manage groundwater across so many water users that the motivation to proceed in that direction is dulled if not ignored.

III. Differences Among Water Districts Which Prevent the Formation of a Consensus for Efficient Groundwater Management

III. A. Introduction

The problem of large numbers exists whether or not there is a strong or weak consensus for collective action.[26] Even a large improvement in group welfare from collective action can be distributed in minuscule shares if the group Is very large, and the transactions costs associated with organizing, motivating, and directing a collective effort grow with the size of the group. A subset of any group upon which the costs of collective action may disproportionately fall, will work against the efforts of the majority who may support the collective action. So, 1n addition to the size of the group and the problems this size brings, it is important to also give attention to the distribution of the costs and benefits among the members of the group. Differences between members of a group (i.e. nonhomogenity of a group) will likewise affect the likelihood of a consensus for collective action among them. An unequal distribution of costs and benefits and other differences among members of a group can result in a lack of concensus for collective action. A lack of consensus for collective action will prevent its fruition regardless of the size of the group.

Two barriers exist to the actualization of collective action, large numbers and variation of members in a group. With the problem of large numbers, the group has an incentive to act but the translation of the group incentive to the individual is lost. With the second barrier, variation within the members of a group, the group incentive may be weak. This section of the chapter questions whether there is a consensus in favor of collective action to control groundwater extraction from the San Joaquin Valley aquifer. Variation in the institutional structure of the Valley's water districts suggests a difference in their willingness to accept

[26] Olson says that "The degree of consensus in a group is sometimes discussed as though it were the only important determinant of group action or group cohesion. There is, of course, no question that a lack of consensus is inimical to the prospects for group action and group cohesion. <u>But it does not follow that perfect consensus,</u> both about the desire for the collective good and the most efficient means of getting it, <u>will always bring about the achievement of the group goal.</u> In a large, latent group there will be no tendency for the group to organize to achieve its goals through the voluntary, rational action of the members of the group, <u>even if there is perfect consensus</u>" (Olson, p. 59, emphasis added).

groundwater management, and this difference will prevent the formation of a Valley-wide coalition supporting efficient ground water management.

III. B. Voting Franchise Differences Among Water Districts

Water districts in the San Joaquin Valley have organizational or institutional differences. Among these differences are the type of voting procedures used to make district decisions, and these voting differences are correlated with differences in the district's willingness to adopt efficient groundwater management, Water Storage Districts and California Water Districts, which restrict voting to property owners and count each vote according to a property-weighted system, dominate the western and southern water-deficient portions of the Valley. Irrigation Districts, which do not restrict voting to property owners, but franchise all residents of the district and count votes according to one-person-one-vote guidelines, dominate the eastern portion of the Valley. The result of having two different forms of water district governance, according to a recent study of political economy of water use, is that[27]

> Two contrasting political systems continue to share responsibility for California's water. One is based on popular elections and the other weights voting according to property owned. In California's rich agricultural lands two distinct economies have emerged. One tends to be characterized by family-size farming and the other is marked by large-scale and corporate farm ownership. There is evidence too that in the state's rural areas two dissimilar societies have taken shape. One is distinguished by farm communities and small businesses and the other is identified with extensive farming and non-resident ownership.

Property-qualified districts, such as those formed under the California Water District Act of 1913, give individuals or corporations with large landholdings considerable political influence. For example, in the Westlands Water District there are 3,000

[27] Merrill R. Goodall, John D. Sullivan, and Timothy DeYoung, California Water, New York: Allanheld, Osmun and Co. Publishers, Inc.: 1978, p. 100.

landowners and 597,779 acres, but 10 landowners account for 43 percent of all the land in the district. Thus, a few corporations and individuals can effectively control district elections. in the Berrenda Mesa Water District in the southern San Joaquin Valley, 17 landowners account for 88% of the district's acreage and 88% of the votes. The situation is even more concentrated in the Tulare Lake Basin Water Storage District where four corporations farm nearly 85 percent of the district's lands, and the J. G. Boswell Corporation alone controls enough votes to determine who is elected to the district's board of directors.[28]

Since 1960 property-qualification districts have increased in number and size at a higher rate than one- person-one-vote districts.[29] In property-qualification districts, private and public interests are inseparable, and decisions are dominated by a few large land-owners. Political characteristics of districts determine who pays the costs of water development, and how the burden of overdrafted groundwater is distributed. The control of public government is in the hands of private organizations (i.e. large scale and corporate agriculture) in the southern and western portions of the San Joaquin Valley where property-qualified districts are dominant. Decisions are made by and for the benefit of the corporate owners of large-scale agriculture.[50]

On the eastern side of the Valley, an area governed predominantly by irrigation Districts, land holdings are relatively small and the farms are operated by local resident-

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[28] Ibid., p, 20-21.

[29] Ibid., p. 96.

[30] Concentrations of landholdings can be beneficial if it eliminates the problem of large numbers by making all groundwater users recognize their Interdependency and work toward efficient groundwater management (increasing the joint benefit of a collective good). However, the concern in this portion of the chapter is with the variances between water districts and how this constrains collective action, not the number of water districts nor the number of water users. The conclusion is that water districts of large landholders are less likely than water districts of small landholders to support groundwater management because their perceived benefits are less for assorted social reasons -- higher discount rate because of competing uses for capital funds, and an inability to capture secondary and tertiary benefits from irrigated agriculture.

owners. Voter turnout is comparatively high and expenses are covered by revenue generation rather than by incurring indebtedness as in property-qualification districts. Decisions are made by and for the benefit of all residents of the district, most of whose sole livelihood depends upon the health of the farming community. Table 6-1 summarizes some of the major political characteristics of and differences between the property-qualification and one-person-one-vote districts in the San Joaquin Valley.

Ironically, the few number of land owners in the western water districts of the Valley will make it easier for them to reach a consensus for a particular type of groundwater management policy and to implement that policy, whereas the larger number of land owners in the eastern water districts will make this more difficult. Though the law of large numbers will assist western water districts in their groundwater management planning, the differences between the eastern and the western water districts makes achieving a consensus on groundwater management for the Valley as a whole extremely difficult.

III, C. Differences in the Financing of District Operations

The chosen means of financing a district's current operating expenses is a behavioral characteristic tied to the franchise pattern in a district.[31] Districts with large landholdings and property qualification for voting tend to incur indebtedness to cover operating expenditures. In addition to their general property tax bill, the passage of various bond issues (to cover operating expenditures or for any other reason) burdens landowners with "standby

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31 Variations in current operating expenses occurs with variation in the availability of surplus water. Seldom do districts possess contingency funds for the purchase of additional surface water made available during surplus water years. To purchase this water, whether used for irrigating additional acres or used for groundwater recharge, districts must raise operating revenues.

assessments".[32] One-person-one-vote districts tend to generate revenue through higher water charges (revenue generation) rather than by incurring increased indebtedness. The tendency of different districts to cover operating revenues by different methods are public policy decisions which affect all members of the water using community.

Property-weighted voting systems are designed to disenfranchise many individuals who otherwise would oppose increased taxes, and thus to spread the costs of water supply projects over many who receive little benefit. Standby assessments and other property taxes which are paid irrespective of the quantity of water used, cover the fixed costs of water projects, so that water users pay a smaller portion of total water costs. The per unit cost of delivered water becomes subsidized by small water users and by residents of the district who do not use irrigation water. The net benefits of water-supply projects fall disproportionately on the large corporate water users of the district because standby and other assessments reduce the user fees they pay, and pass the burden of financing the water projects on to others.

Within the property-qualification districts, the tax schedules that result from incurring indebtedness disproportionately burden the small farming enterprises, and, as a result, the small landowners have been replaced by larger corporate enterprises who can afford the tax burden.[33] The financing policy of property qualified districts further strengthens the large landowners' position as water use decision makers. With regards to overdraft of groundwater as a public policy, the large landowners appear willing to continue overdraft and to accept both the private cost of higher groundwater pumping costs and the

[32] Goodall, et. al.,p. 58. For example, in the Berrenda Mesa Water District, the annual standby assessment ranges from $65 to over $75 per acre whereas the general tax levy is $3 per acre.

[33] ibid., p. 58-59.

social cost of lost irrigated acreage (lost from the bankruptcy of small farmers) caused by the higher groundwater costs.[34]

Just as indebtedness to cover operating expenses is a means of shifting the costs of agricultural water systems to non agricultural users of water, maintenance of common property rights to groundwater allow some water users to shift the cost of their water use on to others. Ability to force others to pay the increased groundwater supply costs due to continued overdraft will be lost given a change in property rights to groundwater.[35] Under private property rights in groundwater, the burden of increased costs due to groundwater extraction falls on the one who extracts the groundwater. As will be developed later, the ability to separate those who benefit from those who pay is a characteristic of distributive politics - - a form of politics practiced by the water users of the southern and western San Joaquin Valley, and a type of politics inconsistent with the policy of efficient groundwater management.

If one area of the Valley assesses the incentive to adopt groundwater management at a higher rate (i.e. the eastern portion of the Valley dominated by Irrigation Districts) than

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[34] According to Andrews and Fairfax, footnote 17, p. 154, "The strength of local Valley opposition to statewide groundwater management legislation, and the Valley's support for importing additional surface water or letting existing agricultural lands go out of production if ground or surface water became unavailable was confirmed in numerous personal interviews between the authors and state and local water officials." The local water officials listed were almost all from the southern and western Valley property qualified water districts. Also see the conclusion to the San Joaquin Valley Agricultural Water Committee's report, San Joaquin Valley Agricultural Water Committee, Water Resources Management in the Southern San Joaquin Valley California. Glendale: Bookman-Edmonston Engineering, Inc., January 1979, p. 66-67, particularly "Senario No. 2 - Continuation of Unmitigated Overdraft".

[35] Adjudication of groundwater rights by a limitation of pumping to a safe-yield percentage of the adjudicated right will force water users to use more surface water than groundwater. Taxing schemes where water users are forced to play the social marginal cost per acre-foot of groundwater pumped would have parallel affects across property-qualified and one-person-one-vote districts. But a taxing scheme that taxed extractions and used that revenue augmented by revenue from property taxes, to purchase additional surface water would advantage the property-qualified districts water users since most of the cost of this additional water is paid for by non-users.

another area of the Valley (i.e. the western and southern portion of the Valley dominated by property-qualified districts), then the likelihood of a consensus on a Valley-wide groundwater management program is greatly diminished. The diminished likelihood is not because the Valley-wide incentive is less, but because of the disparity in the perceived need for such a policy between the two groups who must negotiate a groundwater management plan. Both types of districts in the Valley may have a positive incentive to adopt groundwater management, but agreement on a specific policy proposal becomes relatively more difficult the greater the disparity in the perceived benefits of any policy. In addition, other investment projects compete with efficient groundwater management. The same list of alternative policy proposals will be ranked differently by districts according to the district's discount rate and/or time horizon. Consensus on the most profitable project or desired policy may not be reached given the dissimilarity of project rankings because such a compromise would involve a larger number of negotiations (or side payments), than If all districts had the same ranking of policy choices.

Exercising the ability to cover operating expenses by incurring greater indebtedness suggests that property-qualified districts will calculate a lower incentive to institute efficient groundwater management than one-person-one-vote districts. The property assessments to pay the indebtedness are transferred along with the property to a new owner, and in effect lower the future capital gains from the sale. Lowered future profits (from future capital losses due to diminished property values) are thus traded off against increased present profits. (If the indebtedness was incurred for capital expenditures, the above would not follow from observed differences in means of covering operating expenses, and also assumed here is that the two types of districts have equal recourse to alternative sources of funds). Present profits are increased because present operating expenses are not paid for in the present, but are delayed into the future. Given that both types of districts face the same financing opportunities, this behavior suggests that the large corporate farming enterprises have relatively high discount rates and/or shorter planning horizons. Either a higher discount rate or a shorter planning horizon on the part of property qualified districts results in a reduced incentive to adopt groundwater management because the present discounted value of efficient management will be lowered.

Disparity in incentives to change groundwater property rights is further widened by differences in social-economic factors across the various districts. The market in which corporate agriculture competes is different from the market in which resident farmers in one-person-one-vote districts compete even though they may produce the same products. Corporate resources are invested in corporate farming as long as the rate of return from corporate farming is at least equal to the rate of return those resources could earn in alternative ventures. Owners of corporate farms in the western and southern portions of the Valley, where water is controlled by property-qualified districts, are newspaper companies, insurance companies, petroleum companies, etc. Their opportunity cost of capital may be higher (compared to farmers in other sections of the Valley) since capital used in agriculture means sacrificed opportunities in the newspaper, insurance and petroleum business of the parent company. If the cost of capital differs across the Valley (i.e. the cost of delayed production or delayed use of groundwater), then the cost of negotiating agreements for groundwater use will be increased.

Compared to their counterparts in property-qualified districts, Irrigation District residents make financing decisions which are more stable and have a long-term perspective. Non-monetary benefits such as greater stability and security in the farming community, may accrue to resident farmers in Irrigation Districts. Family farmers, even given the same alternative investment opportunities as corporate farmers, may add non-monetary measures to the returns from farming, and thus accept a lower monetary rate of return in farming (i.e.

they have a lower discount rate).[36] There is some evidence for the existence of these non-monetary benefits. First, capital outlays, which allow for growth in the farming community and provide for future stability as opposed to present benefits, are greater in Irrigation Districts than in California Water Districts and other property-qualified districts.[37] Secondly, in measures of financial behavior covered by Goodall, Sullivan, and DeYoung, the one-person-one-vote districts when compared to property-qualified districts clearly "exhibit much more stable behavior, while the latter were much more oscillatory in character."[38] Democratic control of financial matters appears to promote relatively moderated and stable fiscal policies, and relatively more stable social-economic environments.

Because all the residents of Irrigation Districts are able to vote, additional incentives may exist to encourage adoption of groundwater management in these districts as opposed to property-qualified districts. A failure to adopt groundwater management will increase water costs, lower agricultural profits, lower property values, and hasten the decline of the farming communities. All members of the farming community, not just the water users, will suffer from a failure to eliminate common property use of groundwater. California's Department of Water Resources has estimated that for every dollar directly invested in farming, the general

[36] See Sullivan.Goodall, and DeYoung, Table 3-16, p. 77 and 78 which points out that Irrigation Districts, of the 20 different types of districts state-wide analyzed in their study, "exhibit the lowest profit proportions." Profit, or net operating income, as a proportion of total revenue in 1968 was -. I for Irrigation Districts, and -0.01 for all one-person-one-vote districts, whereas for property-qualified districts the proportion was +. 1.

[37] Ibid., p. 47.

58 Ibid., p. 51-52.

farming community benefits by three dollars.[59] Recognizing their stake in the long-term health of farming and groundwater use will add grass-roots or popular support in the farming community for changing groundwater property rights. Though nonfarmers in property qualified water districts may have an incentive to support groundwater management, they cannot act on this incentive because they are disenfranchised.

III. D. Conclusion

In conclusion, the differences or variations in district behavior add to the difficulty of implementing groundwater management. The more diverse the group, the less likely a consensus will be reached, and if reached, the higher will be the cost of negotiating the details of a particular plan. The problem associated with large numbers (i.e. developing specific incentives to pair individual costs and benefits) is made more difficult if the specific incentives must take into consideration variations across individuals in costs or benefits. It has been assumed that members of public water districts are the ones who will benefit from a change in groundwater property rights and thus that water districts, as representatives of the water users, have an incentive to push for efficient groundwater management. However, it has been shown that not only is there an excessive number of water districts to hinder any movement towards efficient management, but that different water districts have varying incentives to adopt efficient management because of their organizational structures. The next section of this chapter looks at interest groups that have been identified in the San Joaquin Valley - groups not necessarily associated with water districts - and at their activities with

[39] The indirect impact of agricultural dollars on the state is recognized by the San Joaquin Valley Water Committee, who, in analyzing the consequences of losing 600,000 acres due to a decline in the height of the groundwater table, say that "It is estimated that the value of the direct loss would be about $530 million annually, while the impact on the State's economy would be a loss of about $ 1.6 billion annually. The regional impact on the Valley is estimated to be in the order of $ 1.1 billion annually" (p. 67).

regard to changing groundwater rights. It will be shown that not only a lack of consensus in favor of efficient groundwater management has prevented its blossoming in the Valley, but also the prevailing form of politics practiced by the Valley's water-using special interest groups hinders its growth.

IV. Interest Groups and Governmental Involvement in Groundwater Management Policy

IV. A. Introduction

A change in groundwater management techniques from the present common property management to efficient groundwater management requires a change in property rights to groundwater. Property rights establish social relationships, responsibilities, and privileges among individuals, and thus are determined collectively and are institutionalized by government. A change in groundwater management is a change in the social contract that exists among water users, and would require a restructuring of governmental arrangements.

Arthur Maass describes two institutional factors which limit "what is otherwise an area of free choice among alternative governmental arrangements."[40] The first are the technical and economic characteristics of water resource development and the second are the requirements of a constitutional democratic system. The technical and economic aspects of water development in the San Joaquin Valley were discussed at length in the previous chapter, while a discussion of the second factor follows. Under Maass' description of a constitutional democratic system, the community or society has a separate function from the government or the state. The community must agree and establish standards or objectives of common life (i.e. equality and liberty). The government serves the community as it establishes political and economic conditions which allow all to participate, provides institutional means for

[40] Arthur Maass, "System Design and the Political Process: A General Statement," in Design of Water-Resource Systems, edited by Arthur Maass, et al., Cambridge, Mass.: Harvard University Press, 1962, pp.565-604.

translating community standards into laws and rules, and carries out activities in accordance with those standards.

Once the community establishes its standards, interpretation of these standards is carried to successively greater specificity through the electoral, the legislative and the administrative stages of government. There is an assumed division of labor in government which assigns to each stage a deliberate function of its own. In the electoral stage, the community chooses representatives who carry the discussion of its standards to the legislative stage. The legislative process translates the general programs endorsed by the electorate into rules and laws. The legislative stage allows an integration of views not possible at the electoral stage, and the legislative process provides a means of popular control and oversight of the administrative stage. At the administrative stage rules are translated into criteria for government action and this stage provides an institutional means for focusing on particular issues. Despite the specialization of focus within each state, their actions need to be accountable with what goes on in all the other stages, thus preventing any one stage from dominating the others.

Though Maass claims that "one of the objectives of the theory of democratic government presented here is to emphasize the search for consensus on community values, and to deemphasize power politics based on individual interest or interest-group demands",[41] the same theory shows that control of or leverage at one stage of the government by a particular political party or interest group can counteract or forestall any movement at another stage. Despite the economic incentive to manage groundwater, this section of the chapter highlights evidence that the legislative stage of government has been particularly unresponsive to the incentive to manage groundwater.

[41] Ibid., p. 572.

The tradition and design of California politics has allowed interest groups to have a wide degree of influence. Weak political parties, importance of the media and the need for large sums of money for campaigning are some of the reasons interest groups are so strong and influential.[42] The emphasis on local planning and other factors which have created a large number of fragmented and noncooperating water districts also means that water users are not politically represented by any one special interest group. Different interest groups, because of different strengths in areas of popular support, wealth, or technical expertise, come to rely upon different branches of government to achieve their ends.[43] Groundwater management is one end to which different interest groups aspire, but depending upon the interest group's definition of groundwater management, the group will apply its resources to that branch of government which best supports that policy.

The following major interest groups have been identified in the groundwater policy arena: California Cattlemen's Association (CCA), California Chamber of Commerce (CCC), California Farm Bureau (CFB), Association of California Water Agencies (ACWA), Planning and Conservation League (PCL), and the Sierra Club (SC).[44] Of these groups, the corporate farmers are most active in the California Chamber of Commerce (CCC), while other

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[42] Zachary A. Smith. Interest Group Interaction and Groundwater Policy Formation in the Southwest. Lanham.MD.: University Press of America, Inc., 1985, p. 168-9.

[43] Groups with money and/or with large memberships are generally advantaged in the legislative arena; groups with money or with attorneys on staff (technical expertise) are advantaged in the judicial arena; and groups with training or experience similar to administrative staff, or if they are beneficiaries of their services, are advantaged in that arena. In terms of water politics in California, it is not assumed that any one group of water users acts as a power elite, but that some groups of water users have leverage in particular branches of government. The strength of southern California is in its population, and hence strength through the electorate stage. The water users in the Central Valley of California, though numerically small, have disproportionate power at the legislative stage. Environmental groups have been particularly successful in using the judicial branch of government to advance their policies.

[44] Smith, p. 40-41. These groups were identified as the major groups by "individuals within state administrative water agencies known to have been active in the past in groundwater management, conflicts, or litigation."

agricultural interests are active in the California Farm Bureau (CFB) and the California Cattlemen's Association (CCA).[45] These groups often form coalitions which greatly increase their legislative influence, and have combined to counteract the efforts of the administrative branch when they have disagreed with proposed policies.

Groundwater policy, as it is now exercised in the San Joaquin Valley, is for local management which allows individual pumpers and individual districts to pursue privately-determined pumping patterns. Common property access to groundwater is the policy that is supported in the Valley, but a policy that has come under considerable criticism more recently than in the past. The drought of 1976-77 brought some of the costs of the present policy into sharp focus because overdraft in the Valley increased dramatically, and an estimated 10,000 new wells were drilled. In response to fears of future shortfalls in groundwater tables, of increased future pumping costs, and of a loss of agricultural incomes and populations, different interest groups were encouraged to exercise their resources in support of their preferred groundwater management policy. The reaction by the various interest groups to the drought shows what actions they prefer to take in times of crisis, and the type of politics which best suits their needs and abilities.

IV. B. The Politics of Water In California

Throughout California's history, interest groups have been very successful in bringing water use issues to the policy agenda of government. The politics of water for the San Joaquin Valley, and for most of California, has always centered around the same policy --

[45] Ibid., p. 49, The CCC has both urban and rural popular base, rich financial resources, good legislative access, and technical expertise; the CFB has a predominantly rural popular base, is rich in financial resources, has good legislative access and technical expertise; and the CCA has a rural popular base, poor financial resources, poor legislative access, and exercises political strength through campaign contributions. The Sierra Club has indirectly become involved in San Joaquin Valley groundwater management because of its influence through the initiative process in California.

more water. The Valley farmers have been able to get water from the federal government through the Central Valley Project, and they were able to get water from the state of California, with the assistance of urban Southern California, through the State Water Project. In advancing the policy issue of "more water" through the policy process, the interest groups of the Valley have been very successful. The future effectiveness of these interest groups and their prospects for continued success may be changing as the central theme of water policy moves away from the issue of more water and towards the issue of efficient use of existing water.

The difference between the issue of more water and that of better use of existing water can be interpreted as a difference between environmental-regulatory politics and distributive politics.[46] Distributive politics is euphemistically called "pork barrel" politics, is successfully exercised by "log rolling", and results in "Christmas tree" legislation. Distributive politics centers around local issues, seeks to disaggregate those who benefit from those who pay, and forms coalitions based on distributing pieces of the pie only among members of the coalition. Environmental-regulatory politics is comprehensive or inclusive in its scope requiring parties to a coalition to be willing to pay for the benefits received and to recognize secondary or spillover effects of their behavior. Groundwater issues, including such problems as water quality and efficient management, are issues for environmental-regulatory politics whereas surface water questions such as "how much more?" and "from where?" are more successfully answered by the processes of distributive politics.

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[46] For a clear distinction between distributive, (environmental-) regulatory, and redistributive types of politics, see Dean E. Mann, "Political Incentives in U. S. Water Policy: Relationships Between Distributive and Regulatory Politics" in What Government Does, edited by Matthew Holden, Jr., and Dennis L. Dresang, Beverly Hills, Ca.: Sage Publications, 1975, p, 94-123; T. J. Lowi, "American Business, Public Policy, Case Studies and Political Theory" World Politics, July, 1964, and T. J. Lowi "Four Systems of Policy, Politics, and Choice" Public Administration Review, July-August, 1972.

Water politics 1s moving away from distributive politics and into an era of environmental-regulatory politics.[47] This shift has been precipitated by a growing realization of water scarcity at both the federal and state levels of government.[48] No longer does the state have surplus water that can be freely taken and used. Instead, the existence of scarcity creates costs for others given another's use of water. Whereas water policy under distributive politics calls for the distribution of surplus water to all those in the coalition supporting the policy, environmental-regulatory politics recognizes the costs associated with water use, the competition that arises to allocate those costs, and the compromises needed for an equitable and efficient allocation of water. In other words, rather than being a means for the development of new water sources, environmental-regulatory politics arises with the need for efficiency in the use of existing water sources. Efficient groundwater management is a water policy that will be shunned by the practitioners of distributive politics because it recognizes the comprehensive, as opposed to the local, nature of groundwater use and requires collective and cooperative efforts in management rather than insular and independent behavior.

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[47] For a discussion of the difference between these two types of politics as they relate to water development, see Helen Ingram, "Patterns of Politics in Water Resource Development" in Selected Works In Water Resources, edited by Asit K. Biswas, New York: International Water Resources Association, 1975, pp. 291-308 (originally published in Natural Resources Journal 11, 1, (January 1971), pp. 102-118).

[48] At the federal level, water scarcity led President Jimmy Carter to object to nineteen proposed water projects in 1977, and to call for "improved planning and efficiency management of Federal water resource programs" in a June 6,1978 press release. For more on the consequences of Carter's actions, see Dean Mann, "Institutional Framework for Agricultural Water Conservation and Reallocation in the West: A Policy Analysis" in Water and Agriculture in the Western U. $.: Conservation, Reallocation. and Markets, edited by Gary D. Weatherford, Boulder: Westview Press, 1982, pp. 10-14. For a study on the increasing scarcity of water at the state level, see William Kahrl, editor, California Water Atlas. Sacramento: State of California, 1979.

The incongruity between the two modes of politics in terms of water policy is shown in the following observation by Dean Mann:[49]

> The National Water Commission has now issued a report which must send chills up the spines of those who have played distributive politics with western water policy in the past. The commission[50] urges the application of strict economic analysis In the evaluation of all such proposals for interbasin transfers - i.e., that there be clear-cut national economic gains and not simply income transfers and that the beneficiaries pay the full reimbursable cost of the water brought to their region, including compensation to the region that exports the water. Given the fact that the adoption of such principles clearly takes decision-making on water development projects completely outside the distributive framework, there is little expectation that any projects would be authorized on that basis.

Distributive politics has long been used by those interested in the traditional issue of "more water". Surplus water - water available in the northern third of the state (north of a line drawn east and west through Sacramento) but demanded most heavily in the southern two-thirds of the state - has been brought to the San Joaquin Valley first by the Central Valley Project, (expanded to include the San Luis Project, the Cross Valley Canal, and the New Melones Dam) and secondly by the State Water Project. Water supply projects have been implemented as local political forces have been successful in advancing them through the political process, but these projects have made water increasingly scarce as shown by people's willingness to participate in the political process to prevent the construction of new projects The Peripheral Canal (see Figure 6-1) ,[51] considered the next phase of the SWP, has run into repeated political trouble (on the basis that sufficient water is no longer available from the

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[49] Mann, p. 113.

[50] Cf., National Water Commission, Water Policies for the Future. Washington, D. C: U. S. Government Printing Office, 1973.

[51] The Peripheral Canal is designed to divert water from the Sacramento-San Joaquin Delta to the San Joaquin Valley. It would increase the amount of water available to the Valley from both the Central Valley Project and the State Water Project by 1.2 million acre-feet, and it is suggested by Valley water users that the Peripheral Canal's water would alleviate overdraft in the Valley. Opposition to the Peripheral Canal is fear of salt water intrusion into the Delta region of the state, and local opposition to the "export" of water from rivers in the northern part of the state to either the San Joaquin Valley or to Southern California.

northern rivers of the state to provide for both increased water quality in the Delta and additional irrigation water for the Valley). The Peripheral Canal will be used as an example of how a policy successful in the arena of distributive politics fails in the confines of regulatory-environmental politics. However, groundwater management, an environmental-regulatory policy, has not been adopted in the San Joaquin Valley because the special interests in favor of distributive policies have yet to surrender their control of the legislative stage of policy formation.

The piecemeal provision of water, which in California has resulted in a multitude of projects interconnecting local, state, and federal governments, is an attribute of distributive politics. Benefiting specific localities, projects are built in isolation from each other so that the beneficiaries (San Joaquin Valley agricultural and southern urban interests) never are confronted by those burdened by the projects (general taxpayers and northern water users). As the progression of projects began to reclassffy water from a surplus resource to a scarce resource, distributive politics was used as a political defense by those who were providing the surplus water for earlier projects. The County of Origin Law and the designation of northern rivers as wild or scenic rivers were likewise uses of distributive politics as means of guaranteeing to the surplus water areas a fair share of water. Because today's water environment is characterized more by scarcity than surplus, distributive politics is of questionable usefulness because mutual accommodation across many competing coalitions must now be reached if new water-use policies are to be instituted.

The following section explores the policy formation process as it applies to groundwater management. The drought of 1976-77 brought the issue of groundwater management to the policy agenda by rapidly increasing overdraft of groundwater. The practitioners of traditional distributive politics were the first to act on the problems created by overdraft of groundwater by calling for importation of more surface water. Wherever the policy issue of "more water" was advanced, the issue of efficient use of existing water confronted it. And attempts at instituting efficient groundwater management were likewise rebuffed by those preferring more surface water. The result of the battle between the two policies of more water versus efficient use of existing water was that neither was provided to the San Joaquin Valley. The policy issue of efficient groundwater management has not been proposed in isolation of other water use issues, hence in what follows the forces acting on other issues, such as the Peripheral Canal, are assumed to be similar to the forces determining the fate of groundwater management in the Valley.

IV. C. Groundwater Management as Policy in California Politics

IV. C. 1. Peripheral Canal - Senate Bill 346 and Senate Bill 200.

In their study of groundwater institutions in the southern San Joaquin Valley, Andrews and Fairfax noted that "most districts are highly aware of the current groundwater situation. They know the critical importance of groundwater to their constituents, and they are aware that future groundwater problems may force alterations in the traditional institutions governing groundwater use in the southern Valley."[52] When facing groundwater supply problems[53] in the past, water districts have been successful at all levels of government in gaining additional water supplies. In response to groundwater overdraft in the late 1920's, the Central Valley Project was approved by the state of California and by the federal

[52] Andrews and Fairfax, p. 200. But they go on to conclude that "the experience in the Valley suggests that the institutional form of local water districts is a relatively unimportant variable in understanding the dynamics" of groundwater management (p. 202).

[53] Overdraft of groundwater is considered to be a problem of inadequate groundwater supply by Valley water users. Groundwater supply problems are interpreted as problems with the cost of groundwater extraction given a fixed demand. Assuming an inelastic demand for groundwater, a decrease in supply will cause an increase in the cost of groundwater. To return groundwater costs to their previous level, an increase in supply has been called for. Little attention is given to controlling demand as a means of controlling groundwater extraction costs.

government. When the recurring groundwater problems resurfaced in the late 1950's the State Water Project was approved by the state legislature, supported by Governor E. G. Brown, and funded by the electorate via the state's initiative process. The drought of 1976-77 again brought the issue of groundwater overdraft to the forefront of the political process, but this time the political environment was entirely different from that of the early and middle decades of the century.

The vote on Proposition 1 in November of 1960 to finance the SWP won a narrow popular majority due to the overwhelming support of the urban communities south of the Tehachapi Mountains. The San Joaquin Valley counties of Madera, Fresno, Kern, and Tulare voted in support of the SWP, but only by very narrow majorities. The Department of Water Resources was made responsible for the SWP and for providing water to water districts under long-term contracts. The water contracts for SWP water were intended to promote agricultural growth in the San Joaquin Valley, but because of the high cost of its water, Valley farmers only reluctantly supported the SWP. Growth in the Valley was encouraged by the DWR through the selling of "surplus" water at reduced prices. Much of this water is under contract to the Metropolitan Water District, but since it cannot sell the water within its boundaries at this time, the water is made available to western San Joaquin Valley water districts for only the cost of transportation of the water from the Delta to the district.

Water supplies available to the San Joaquin Valley are expected to dwindle. The MWD is expected to increase Us use of SWP water in the near future, and more water is expected to be needed to maintain water quality in the Delta. The Peripheral Canal was proposed as a means of supplying sufficient water to meet the long-term contract demands of Valley farmers. Senate Bill 346 (SB 346), which included the Peripheral Canal among its many features, was introduced on February 18,1977. Also in the bill were provisions to store water in underground basins and to relieve groundwater overdrawing problems in the San Joaquin

Valley.[54] Overdraft in the San Joaquin Valley is approximately 1.5 million acre-feet, and the Peripheral Canal was to bring 1.2 million acre-feet to the Valley, half of which was already under contract.

Provisions in SB 346 for surface water storage in groundwater basins raised the threat to Valley farmers of state control over groundwater pumping. Groundwater in storage is owned in common by all who own land overlying the storage basin under the accepted groundwater law of the San Joaquin Valley - the Correlative Rights Doctrine. But as established in ~~Niles Sand and Gravel Co. v. Alameda County Water Storage District~~ and in ~~Los Angeles v. San Fernando~~, those who undertake storage of surface water in groundwater basins have an exclusive right to that water and they can prevent others from harming that right.[33] Though SB 346 did not directly address the issue of ownership to groundwater or of controls over the right to extract water, because the Governor's Commission on Water Rights Law (which called for greater state controls over groundwater extraction in overdrafted basins) took place during the debate on SB 346, the issue of ownership and state management became part of the debate over SB 346. As for the state's position, Ronald Robie, director of the Department of Water Resources, expressed his position by saying, "Water is a public resource. Therefore, the traditional conception that water right is a property right subject to minimal government regulation must be changed so that a right to use water is created by the state acting in the public interest."[36]

San Joaquin Valley farmers preferred new dams and more surface water at subsidized prices instead of groundwater management, and the agricultural lobby was officially opposed

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[34] John N. Barbour, "Water Politics in California: The Peripheral Canal Bill" unpublished Ph.D. dissertation, University of California, Santa Barbara, 1982.

[35] Furthermore, the storage water is said to be on top of any water already in the basin. Any extraction in excess of recharge which lowers the water table would increase the depth to the stored water, and thus damage the legal and economic rights of those who stored the water.

[36] Statement quoted from Sacramento Bee, March 20,1979. See Barbour, p. 325.

to even a moderate program of groundwater control.[37] However, the water supplied by the SWP, counting the additional water due to SB 346, was projected to exceed water demand until the year 2000. Passage of SB 346 was promised to provide irrigation water to the San Joaquin Valley farmers, and this water would be available at subsidized prices. On the other hand, efficient groundwater would not provide subsidized water, but would reallocate water use across time so that income earned from groundwater use is maximized. To get the carrot of additional surface water, water users would have to endure a hit with the stick of efficient groundwater . Despite the Valley's reluctance to accept the groundwater management provisions of SB 346, the prospects of additional surface water drew them to support SB 346.

It was not the groundwater provisions of SB 346 that eventually led to its demise, however. Agreement between the federal government and the state of California over water quality in the Delta was to result in plans to decrease the water available for export from the Delta to the San Joaquin Valley. The proposed re-allocation of water from Valley use to Delta use made the need for additional water for the Valley more imperative than before. All legislative members from the San Joaquin Valley supported SB 346 as a means of securing additional surface water supplies - supplies to replace water redistributed to the Delta and supplies for continued growth of irrigated agriculture.

After the bill was passed from the Senate to the Assembly, the Assembly added amendments to the bill which were to eventually turn the San Joaquin Valley's support away from the bill. Amendments to protect North Coast rivers, and to provide coordination between the CVP and the SWP to maintain water quality in the Delta, were interpreted by Valley representatives as guaranteeing water for the Delta, but guaranteeing no water for agricultural interests in the San Joaquin Valley. Because of the restriction written into the bill limiting the amount of water released to the Valley in the event of a drought, the Valley

[57] Barbour.p. 325.

felt they were not getting enough water from SB 346 to warrant supporting it, and they optioned to wait until a different administration was in Sacramento which would support a bill to provide them with more water.[58]

Opposition to the amended version of SB 346 became widespread throughout the Valley. Opposition was expressed by many water districts, the California Farm Bureau Federation, agribusiness corporations, small farmers, and the Senate Republican Caucus (though all Senators from the Valley at this time were Democrats) among others.[59] The Salyer Land Company had already gone to court to prevent the use of stored CVP water to flush the Delta, a provision of SB 346, and along with the Boswell Corporation, they had supported a bill (SB 1477) introduced by Senator Campbell to remove the Eel River from the Wild Rivers Act so that three dams could be built on the river to provide new water for the Valley. In order to defeat SB 346, the Salyer Land Company hired Donald Kent Brown, one of the highest paid lobbyists in Sacramento.[60] With this support, the opposition to SB 346 had significant financial backing and effective lobbying.

When SB 346 left the Senate for the Assembly, the three senators from the Valley supported the bill, but when it returned from the Assembly complete with amendments, all

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[58] Because the facilities in the bill required state financing, the measure required a two-thirds majority to pass any part of the legislature. The bill first passed the Senate 28-9 in June of 1977 with all three Senators from the Valley voting in favor of it. The amended version of the bill passed the Assembly three months later 58-21 with Assemblymen Richard H. Lehman (Democrat from the 31st district), John E. Thurman (Democrat from the 27th district), Gordon W. Duffy (Republican from the 32nd district), Kenneth L. Maddy (Republican from the 30th District), and William M. Thomas (Republican from 33rd district) voting <u>against</u> it. Later that same month, the bill fails to maintain its two-thirds majority support in the Senate, and fails 21-16 with all three Senators voting against it. The Lehman/Zenovich amendments were added to the amended bill in an attempt to recapture the support of the Valley, but in February of 1978 the bill was put to rest by a vote of 20-14, with Zenovich and Stiern voting in favor but Vuich against.

[59] Barbour, p. 412-414.

[60] Ibid., p. 391.

three - Senators Stiern, Yuich, and Zenovich - voted against the bill.[61] The bill was defeated because the amended version was perceived as preventing needed water from reaching the Valley, again because of the priority given by the federal and state governments to meeting state water quality standards for the Delta.[62] These water quality standards were to be met even in times of drought, placing the greatest restrictions on water movement into the Valley at a time when they would most need it. Distributional politics (the promise of more water) gave life to SB 346, but environmental-regulatory politics (recognition of interdependencies in water use) killed it.

Techniques of distributional politics, long successful for the San Joaquin Valley and still practiced by its representatives, no longer worked when environmental-regulatory politics were necessary to cope with the conflicts borne of water scarcity. Water resources, both surface and groundwater, are no longer in surplus, hence effective coalitions cannot be formed through allocation of a surplus.[63] This change to a new political.environment is explained by Barbour as follows:[64]

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[61] All three Senators representing the Valley were Democrats. George N. Zenovich was from the 14th District which includes Fresno, Madera, Mariposa, Merced, and Stanislaus counties, Rose Ann Vuich was from the 15th District which includes Fresno, Kern, Kings, and Tulare counties, and Walter Stiern was from the 16th District which includes Inyo, Kern, Los Angeles, and San Bernardino counties.

[62] Barbour, p. 411. Barbour's central thesis involves the coalition between urban areas south of the Mountains and northern water users in support of SB 346. Because the Valley, which originally sided with the southern urban interests, bolted from the coalition, joint north-south support for the bill no longer existed, and it was failure to continue north-south support that led to the defeat of SB 346. However, dividing the north-south coalition at the Mountains is a rather artificial division. Most water users can be found south of the Delta and areas from which water can be supplied are north of the Delta. A north-south split of the state at the Delta is more realistic, and Barbour's main thesis, that a coalition was broken and so too was support for SB 346, would remain unchanged.

[63] Water scarcity is a fact of California's long-run and future water supply situation, notwithstanding the claim by the USBR that they have surplus water. Temporarily non-contracted for water, which exists because of the price charged for water from their New Melones project, does not eliminate the state's scarcity of water supplies.

[64] Barbour, p. 447.

> ...by 1977 the political environment was different (than existed when the initial features of the SWP were authorized). Water development was now perceived as a win-lose situation. Regulatory politics was now influencing water development. As the voting breakdown indicates, attitudinal barriers existed. Partisan politics, regional rivalry, and lack of mutual trust, along with environmental and economic concerns, prevented the establishing of a coalition of sufficient size and strength to secure the passage of Phase II (SB 346) of the SWP.
>
> ...Water politics in California was firmly entrenched in the new political arena with new political actors.

Water can be used for either Delta water quality or for agricultural uses in the San Joaquin Valley. Scarcity of water denies unlimited water for both uses and creates a zero-sum game for competing water users. Since there is not enough water for both uses, a choice must be made. Because a compromise could not be reached between Valley and Delta Interests, neither side gained any water from SB 346. Additional water sufficient for both needs is available only by tapping rivers protected by the Wild Rivers Act, and it seems unlikely that enough political strength exists to weaken this act.[65]

After the failure of SB 346, Senate Bill 200 (SB 200) was introduced by Senator Ayala on January 15,1979. SB 200 authorized numerous new water projects and contained limited groundwater storage programs.[66] Many of the same water supply features of SB 346 were found in SB 200 with federal responsibility for Delta water quality being eliminated as a threat to water supplies made available to the Valley. All Valley Senators voted in support of

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[65] Since completion of the New Melones Reservoir and other federal projects, the Central Valley Project has claimed it has surplus water - a result of the high price of water from the New Melones Reservoir relative to other CVP water. The Coordinated Operation Agreement signed in November of 1986 by the Department of Water Resources and the Bureau of Reclamation allows the State to buy water from the CVP for SWP contractors, and has the potential of providing additional water for Valley irrigators while allowing a reduction of water taken from the Delta. However, completion of the New Melones Reservior was not without serious political challenge by environmentalists.

[66] See California Department of Water Resources, The California State Water Project - Current Activities and Future Management Plans, Bulletin 132-80, Sacramento: Department of Water Resources, 1980.

SB 200 as it passed through the Senate (by a vote of 24 to 12), but environmental opposition in the Assembly and in the northern and Delta areas of the state remained. To offset concern over the environmental impacts of SB 200, Proposition 8 was passed by the voters on November 8, 1970. Proposition 8 added to the state constitution provisions to protect northern California's environment should the Peripheral Canal be built.[67] Proposition 8 was a means of amending SB 200 but this amendment did not go through the legislature where agricultural interest groups have their greatest strength, but were approved directly by the electorate where the strengths of environmental interest groups are favorably advantaged.

Again, as with the Assembly amendments to SB 346, the environmental restrictions placed by Proposition 8 upon water supplied by SB 200 brought opposition to the bill from the San Joaquin Valley agricultural interests. The California Farm Bureau voiced opposition to the bill because Valley farmers were unconvinced that SB 200, in conjunction with Proposition 8, would provide them with sufficient additional water to meet their needs. Typical of Valley concerns were those expressed by The Tulare Lake Basin Water Storage District, the major SWP contractor in the southern San Joaquin Valley, whose position was that further water development promised in SB 200 was too uncertain and too expensive to warrant supporting a compromise.[68] Ironically, SB 200 was defeated by another referendum put to the voters 1n June of 1982. A coalition of environmental groups who still opposed the Peripheral Canal despite Proposition 8, and the Valley's agricultural interests who were unsatisfied with water supply guarantees of SB 200, combined to place Proposition 9, to repeal both SB 200 and Proposition 8, on the June 1982 ballot.

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[67] These protections included a prohibition against statutes that would reduce the environmental quality of the Delta and San Francisco Bay, and prohibited extraction of water from the Wild and Scenic River system except by a vote of the people or a two-thirds vote of the legislature.

[68] Position statement based on an interview with Stanley Barnes, at the time of the J. G. Boswell Land Company; See footnote no. 190, p. 186 of Andrews and Fairfax.

The passage of Proposition 9 ended another water development compromise package and left the future of the SWP in some disarray. It may not be true that the agricultural interests intentionally disrupted groundwater management plans in the Valley by refusing to accept any water management compromise not guaranteeing massive quantities of additional surface water, but this was, nevertheless, the effect of the defeat of SB 200. By 1980 the SWP was approximately 2 million acre-feet short of its future contractual commitments to areas of the state south of the Delta, a shortage which hinders the state's groundwater management options. The effect of a lack of surface supplies, and of no institutional mechanisms to force groundwater management upon the Valley, means that overdraft will likely continue. The prospects for groundwater management in the San Joaquin Valley were summarized by Andrews and Fairfax as follows:[69]

> Activities to date do not, however, bode well for groundwater management enthusiasts in the DWR. Part of the SWP's failure to alleviate groundwater overdraft results from the relatively high price of state water. As already discussed, this situation is likely to worsen in the future. Moreover, although the DWR arguably has authority which it could try to exercise, the simple fact remains that it is a water development and delivery agency with only half enough water to meet its contractual obligations for surface water. Absent a clearly defined solution to the DWR's supply quandry, its influence in groundwater matters may diminish rather than expand.

Valley water users appear to support only legislation which provides them with additional water. The stronger the single-minded demand for more surface water, the higher the costs that will be endured before this demand is either abandoned or compromised. According to Andrews and Fairfax, that cost may be very high: "The strength of local Valley opposition to statewide groundwater management legislation, and the Valley's support for importing additional surface water or letting existing agricultural lands go out of production if

69 Andrews and Fairfax, p. 242.

ground or surface water became unavailable was confirmed in numerous personal interviews between the authors and state and local water officials."[70]

The lack of a consensus on the desirability of groundwater management by those who would most benefit from it is evident in the opposition to SB 346 and SB 200 by the San Joaquin Valley's water uses. As a result of this opposition, no new surface water prospects are available in the near future, and groundwater management also seems unlikely. However, if the hypothesis that environmental-regulatory politics will replace distributive politics because of the emerging scarcity of water is correct, it may be possible that groundwater management will be accepted by the Valley as a condition of receiving additional surface water supplies. But though the remnants of distributive politics are ineffective in providing additional surface water to the Valley, they appear, as will be shown in the following section, strong enough to prevent the imposition of efficient groundwater management in the Valley.

IV. C. 2. Governor's Commission to Review California Water Rights Law and Senate Bill 95

The administrative branch of government also had a political response to the drought of 1976-77. Governor Edmund G. Brown, Jr. organized the Governor's Commission to Review California Water Rights Law following the drought.[71] The commission recommended statutory groundwater management, simplified adjudication procedures in groundwater suits, use of groundwater basins for underground storage of water, and local responsibility for groundwater management "but within a framework that would protect state interests". Though the Commission stressed the importance of local control over groundwater management

[70] Ibid., footnote 17, p. 154. Also see San Joaquin Valley Water Committee.

[71] For a summary of the commission's report and the subsequent legislative response, see Arthur L. Littleworth, "New Legislation in California and Its Effects" in Proceedings of the Thirteenth Biennial Conferences Ground Water University of California Water Resources Center Report No. 53, November 1981, Davis, Ca.: University of California Water Resources Center, **1981, p.46-52.**

programs, local groundwater management plans would have to be approved by the State Water Resources Control Board (SWRCB), and the SWRCB could ask the Attorney General for judicial relief if local management programs failed to meet state objectives.

More than nine bills were introduced between 1978 and 1981 to implement one or more recommendations of the Governor's Commission, but not one bill addressing groundwater management or the recommendations of the commission were passed.[72] Senate Bill 95 (SB 95), a bill designed to simplify judicial procedures for groundwater adjudication, shows the fate of environmental-regulatory policies in an arena of distributive politics. It will become clear that reaction to the Governor's Commission and to SB 95 clearly shows that efficient groundwater management is not accepted by water using interest groups in the San Joaquin Valley, and that despite the economic incentive to efficiently manage groundwater, no consensus on this policy has yet been reached.

SB 95 was introduced by Senator Presely on January 5, 1981 to provide simplified judicial procedures for basin adjudication. Following the Commission's recommendations, the bill sought to give legislative support and approval to the judicial procedures for granting groundwater rights as established in existing court cases involving the issue of groundwater management. Under SB 95, (1) groundwater rights in overdrafted basins were to be allocated primarily on the basis of recent use (e.g. 5 years continuous use as was established in the West Coast Basin and Pasadena v. Alhambra cases): (2) pueblo rights (as in Los Angeles v. San Fernando) and the right to recapture imported water stored in a groundwater basin (as in ~~Niles Sand & Gravel Co. v. Alameda County Water District~~) were given priority over other uses; (3) no rights were reserved for any prospective overlying uses (contrary to the Chino Basin adjudication); (4) the court could enjoin extraction in excess of the available supply,

[72] Ibid., p. 49. The bills were SB 1505.AB 442, AB 835, AB 1328, AB 3392, SB 1361.AB 2981 .SB 95, and SB 200.

and groundwater rights holders would share proportionately in any aggregate reduction in extractions (as pioneered in Pasadena v.Alhambra) (5) preliminary injunctions could be used prohibiting increased pumping in basins with long term overdraft, (6) the five-year dismissal rule in the adjudication of prescriptive claims would be eliminated, and the court would retain jurisdiction to modify the final judgment to meet demands of changing circumstances (as in the watermaster services provided in West Basin and other adjudicated basins in the Los Angeles Basin). These provisions of the bill changed nothing with respect to accepted groundwater adjudication procedures, but would have codified them and essentially eliminated common property provisions of the Correlative Rights Doctrine. Though these proposals did not meet with resistance during the Governor's Commission hearings, once the proposals reached the legislature, they were forcefully opposed by the Valley's groundwater users.

According to Arthur L. Littleworth, a member of the Governor's Commission to Review California Water Rights Law,[73]

> ...opposition to SB 95 was swift and severe. San Joaquin Valley farmers perceived SB 95 as an unprecedented threat to property and water rights directed at the San Joaquin Valley groundwater basin. Their position has always been that additional surface water is needed to correct groundwater overdraft, and they saw SB 95 as a rationing device which would permit state and judicial interference. The California Farm Bureau was opposed to the possibility it felt the bill created that the state would institute a groundwater adjudication. The Association of California Water Agencies objected to the bill as providing unnecessary limitations and adjudications that served no useful purpose, and causing a 'rush to the pump house, and finally, failing to address the need for more water.

In addition to the rather broad based opposition to SB 95, the Governor's Commission also sparked a more specific reaction by the larger farmers in the San Joaquin Valley. The San Joaquin Valley Agricultural Water Committee was formed, and it employed Bookman-Edmonston Engineering, Inc. to draft a report "to provide a factual basis for use by the

[73] Ibid., p. 50.

Legislature, State and Federal administrations and general public in furtherance of sound programs of water resource development."[74] According to the San Joaquin Valley Agricultural Commission, the report was necessary because "The (Governor's) Commission has proposed legislation which, if adopted by the Legislature, would drastically alter present concepts of ground water law and would repudiate existing State policy with respect to water resource development." The existing State policy is acceptance of groundwater "mining" under common property rights, and the proposed changes would eliminate overdraft by eliminating common property rights to groundwater.

The San Joaquin Valley Water Commission's report called for continuation of water resource development as set forth in the Department of Water Resources' Bulletin No. 3 entitled "The California Water Plan". According to the report, "continued productivity of the present irrigated area and a nominal enlargement of this area" would be possible by building the Peripheral Canal and other projects of the California Water Plan to provide additional surface water to the San Joaquin Valley.[75] Inasmuch as the recommendations of the Governor's Commission and the subsequent proposed legislation were a threat to the prospects for continued surface water development, the financial and technical-expertise strengths of the large land-ownership water districts, as represented by the San Joaquin Valley

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74 San Joaquin Valley Agricultural Water Committee, p. 3.

75 Ibid., p. 4.

Agricultural Water Committee[76], were marshalled to defeat SB 95 and other similar legislation.

SB 95 should not be seen as a legislative enactment to simply assist the judicial branch in carrying out its duties, but as a transfer of power in the area of groundwater management from the legislative branch to the judicial branch. By designating the procedures by which groundwater adjudications would be based, SB 95 would have eliminated bargaining strength of those parties whose groundwater use does not follow the bill's criteria. Since delivery of Central Valley Project water to the Westlands Water District and to other areas on the west side of the Valley, overdraft has become negligible because the subsidized federal water is much cheaper than groundwater. Hence, surface water has been substituted for groundwater, and groundwater pumping has subsequently dropped in volume. The court's determination of groundwater rights based on actual use over a five year period would disadvantage these areas, particularly when compared to the capacity of their wells.

Furthermore, the areas of the Valley owned by the large landowners are the only areas of the Valley with substantial amounts of potentially irrigated land. These lands would be cut off from irrigation by groundwater if adjudication of rights were to proceed as outlined by SB 95. More water, a policy of distributive politics, is still the concern of these water users in the Valley. SB 346 and SB 200 bridged the issue of groundwater management and the provision of more water, but were politically unsuccessful. SB 95, a policy of

[76] Positions held by members of the Committee are manager of the San Luis Water District, engineer-manager of the Kaweah Delta Water Conservation District, manager Tulare Lake Basin Water Storage District, assistant manager of Westlands Water District, watermaster of Kings River Water Association, engineer-manager of Lower Tule River Irrigation District, engineer-manager Buena Vista Water Storage District, general manager-chief engineer Madera Irrigation District, manager Kings River Conservation District, engineer-manager Arvin-Edison Water Storage District, engineer-manager North Kern Water Storage District, and two consulting engineers from the Yisalia-Porterville area. Notice that of the 10 water district members on the Committee, 2 are from popular-elected districts and the other 8 are from property-qualified districts.

environmental-regulatory politics, was also politically unsuccessful. However, If environmental-regulatory politics replaces distributive politics because of the emerging scarcity of water, it may be possible that efficient groundwater management will be accepted by the Valley either as a condition of receiving additional surface water supplies or as a means of maximizing their returns from groundwater use. The prospects for efficient groundwater management and the role of environmental-regulatory politics will be discussed in the following section.

IV. D. Prospects for Efficient Groundwater Management in the San Joaquin Valley.

An appreciation of the difficulties of implementing groundwater management may be gained by an examination of the broad classification of natural resource policy under which groundwater management falls. Groundwater management is a "conservation policy". Conservation of a natural resource means "wise use" of a natural resource. Though the term "conservation" has fallen out of vogue because of its various and unclear meaning, conflicts over what constitutes wise use highlight the difficulty of instituting groundwater management in the San Joaquin Valley. The difficulties specific to groundwater management are difficulties common to all policies to conserve natural resources.

The following answer to the question "What is conservation?" is offered:[77]

> ...the goal of conservation policy is to adjust outputs through time in such a way as to maximize the return from all resources at the disposal of society. In the process of doing this, some resources will be used up, perhaps "completely," and there may be a gradual transformation of "natural" resources into man-made capital "goods" of many different types. To put it differently, this view of conservation policy equates it with "wise use of resources."

[77] Orris C. Herfindahl, "What Is Conservation?" in Readings in Resource Management and Conservation edited by Ian Burton and Robert W. Kates, Chicago: The University of Chicago Press, 1960, p. 232. This article is reprinted from "Three Studies in Mineral Economics," Washington: Resources for the Future, Inc., 1961. pp. 1-12.

> This is a view that enjoys considerable currency. If carefully adhered to, it avoids what we have called the main difficulty in usage, for on this view you cannot say that a certain policy represents "true conservation" until a complete economic analysis of its effects has been attempted, and no reasonable person can ask for more than that. But to equate conservation with "wise use" is to attain a defensible usage only by assimilating the problem of conservation completely into the general economic problem of maximizing output and by departing radically from the everyday meaning of the word "conserve."

A complete economic analysis includes not only determining the net present value from a proposed policy, but also requires taking Into consideration the transactions costs of adopting that policy. These components of a complete economic analysis have been conducted within the above three chapters. The results suggest that despite the economic returns to be gained from efficient groundwater management, the transactions costs associated with such a policy are too great to be overcome from the point of view of the resource users.

Natural resource policy, or conservation policy, is rarely a grass-roots type of policy, i.e. a policy developed by and passed through the political process by those who use the resource.[78] Instead of being a grass-roots policy, conservation policy has been an elitist type of policy -- a preaching of the gospel of efficiency by the government to the resource users.[79] According to Norman Wengert,[80]

> The history of resource policy is the history of science and technology in the service of the nation. The political struggle marking that history has involved scientists and intellectuals whose object largely has been to convert the public and the politician to a recognition of the importance and significance of the results of science. The struggle represents the deliberate attempt of intelligence to subdue and control the environment.
>
> Fundamental conflicts developed between those who sought to know and determine the future, to anticipate scarcities through rational analysis and

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[78] However, once policies are in place, users are very adept at capturing the upper hand in institutional decision making. Rent-seeking behavior of natural resource users generally initiates after the government bureaucracy is in place.

[79] Samuel Hays, Conservation and The Gospel of Efficiency, Boston; Harvard University Press, 1959.

[80] Norman Wengert, Natural Resources and the Political Struggle, New York: Random House, 1955, p. 4.

> calculation, and, on the basis of this knowledge, to determine resource allocations deliberately and thoughtfully, and those who for many reasons preferred to continue relying on private action and drift and to meet new problems on an ad hoc basis, improvising as the situation seemed to require. This conflict remains a chief characteristic of resource politics today....

In the above paragraph, Norman Wengert was describing the conflict between distributive politics (preferring to meet new problems on an ad hoc basis) and environmental-regulatory politics (anticipating scarcity and use of rational analysis). The same conflict he viewed over 30 years ago still continues today over the issue of groundwater management 1n the San Joaquin Valley. Distributive politics, which has been successful in solving groundwater overdraft problems by the importation of additional surface water, appears no longer feasible given the high value attached to undeveloped water sources by environmentalists and northern Californians. How then is efficient groundwater management to be instituted? A possible answer lies in the mechanisms of environmental-regulatory politics outlined below.

John Kingdom has outlined the techniques of policy formation as interpreted in terms of environmental-regulatory politics.[81] He argues that three distincf'streams" must converge for a policy to successfully pass through a policy formation process. If one of these streams fails to merge, the confluent political force behind an environmental-regulatory policy will fail to carry the policy over the constraints presented by the status quo. The three streams are a politics stream, a policy stream, and a problem stream. The problem stream acknowledges that some dilemma or crisis exists for which a policy response is warranted. A policy stream generates the ideas that lead to specific, feasible, and defensible proposals, and in the politics stream various groups become receptive to a particular approach to solving the aforementioned problem in a particular way. Only with a sufficiently strong and active

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[81] John W. Kingdom, Agendas. Alternatives. and Public Policies. Boston: Little, Brown, and Co., 1984.

coalition of support can the policy victoriously emerge from Maass' electoral, legislative, and administrative arenas of government.

In an application of Kingdom's theory on policy formation, Barry G. Rabe studied various types of environmental management institutions at the state level.[82] He discovered that successful innovations in "integrated environmental management" required the idea of integration to emerge from the policy stream, backed by a constituency (from the political stream) that generally was led by state environmental officials, and a triggering event (the problem stream) that gave incentive for a "policy entrepreneur" to carry the policy through the policy formation process.[83] In this interpretation of environmental-regulatory politics, not only must a supportive constituency be able to give political life to an idea, but a triggering event or crisis must transform an idea into a solution to a problem. A triggering event must not only capture the attention of policy makers, it needs to create a political stream receptive to previously dormant ideas, and expose failures and flaws in existing policy, and encourage a political entrepreneur to champion the idea through the policy process.

The drought of 1976-77 was a triggering event which led to many proposals for groundwater management, but the triggering event was too short-lived to be effective in reversing fifty years of surface water rescue policy. Not only was the drought quickly ended, but it was followed with a number of extremely wet years, which is not unusual given California's weather history. Despite the existence of a triggering event of crisis proportion, no policy entrepreneur emerged to pull the three above mentioned streams together. Since the drought was short-lived, so too would have been the political life of any political entrepreneur

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82 Barry G. Rabe, Fragmentation and Integration in State Environmental Management, Washington, D. C: The Conservation Foundation, 1986.

83 See Ibid., figure 4.1, p. 70, for a summary of four innovations in integrated environmental management.

whose career relied upon mediating the problems associated with the drought. Perhaps a longer if not more severe drought will be necessary to precipitate a change in groundwater management institutions in the San Joaquin Valley.

Groundwater management is a type of integrated environmental policy similar to those studied by Rabe. Its successful implementation requires the confluence of the political, policy and problem streams. The drought of 1976-77 was a crisis, but of insufficient length to trigger and continue sufficient political force to institute efficient groundwater management in the San Joaquin Valley. The initial response to the problems caused by the drought was a call for additional surface water (i.e. SB 346 and SB 200). By the time those proposed solutions had been rejected, the drought was over and forgotten, and so too were the proposals and prospects for efficient groundwater management.

Certain established policies are more resilient to repeated crises than are others. The policy of more surface water as a solution to groundwater overdraft has a long tradition and history in the San Joaquin Valley. Severe and long-term overdraft problems in the late 1920's were solved by the Central Valley Project, and the severe and long-term overdraft problems of the 1950's were solved by the State Water Project. The surface water rescue solution to current and future overdraft problems will become an increasingly more expensive solution because of the scarcity of available water for such a solution. The discussion surrounding the Peripheral Canal shows that new and innovative solutions are needed. The world in which California's water users live has become smaller and more crowded, putting a premium on efficient and integrated use of the state's water resources. As a solution to the problems of groundwater overdraft, surface water rescues are an issue of distributive politics, whereas efficient groundwater management is an issue of environmental-regulatory politics. When environmental-regulatory politics emerges as the dominant means of solving the state's water use problems, the policy of efficient groundwater management can be implemented.

V, Conclusion

This chapter has explored three constraints to the instituting of efficient groundwater management in the San Joaquin Valley. The first is the large numbers of water districts, the second is the variability in the organizational and behavioral characteristics of these districts, and the third is the dominance of distributive politics as a means of solving overdraft problems. These problems represent a sequence of hurdles which must be overcome. The last constraint suggests the lack of a willingness to support efficient groundwater management because the techniques of distributive politics and the characteristics of efficient groundwater management are not in harmony. Even if a willingness exists, variability in organizational characteristics of water districts makes agreement on any specific policy proposal difficult to achieve. And the problem of large numbers suggests that even if a consensus in favor of efficient management does exist, collective action in its support is unlikely to be forthcoming.

These constraints are not independent of each other. This independence, nevertheless, may work to the advantage of those who seek efficient management of groundwater. A prolonged drought of crisis proportions may spark environmental-regulatory politics to the forefront of California water politics. A policy proposal that correctly tailors "specific incentives" to account for the variability across groundwater users of the Valley may succeed in gaining enough momentum to pass through the policy process. The establishment of private property rights to groundwater, as is the design of adjudications based upon prescriptive rights, is just such a policy.

Michael Glazer, chairman of the California Water Commission at the time of the 1976-77 drought, had the following to say about the prospects for groundwater management in the San Joaquin Valley:[84]

> In the past, most of our water cases have involved relatively distinct ground water basins in southern California, but our major current problem area ... (the San Joaquin Valley)... contains nine significant interrelated basins, the biggest of which covers 13,500 square miles, 11 counties and substantial numbers of water districts and other governmental agencies. It is hopeless to even talk about adjudication in such an area.

Adjudication of rights over the whole area may be prohibitively expensive, but the Governor's Commission to Review California's Water Rights did suggest legislation which would establish groundwater management programs in the Valley through a locally oriented but integrated system.[85]

Though the suggestions of the Governor's Commission were not implemented, they provide a foundation upon which future groundwater management may be instituted. On the basis of investigation and study by the Department of Water Resources, the Legislature would be able to establish groundwater management area boundries. Areas could be designated as inactive or active. Those areas that are already well-managed or that do not have critical groundwater problems may be defined as "inactive" because they will not be required to have a designated groundwater managment authority or a groundwater management program. The "active" areas must create a groundwater management authority and a groundwater management program.

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84 Michael Glazer, "Reflections on California's Groundwater Management" in Eleventh Bienniel Groundwater Conference, University of California Water Resources Center, Davis: Water Resources Center, 1977, p. 155.

85 See Governor's Commission to Review California Water Rights Law, Groundwater Rights in California, Staff Paper No. 2 by Anne Schneider, Sacramento: Governor's Commission to Review California Water Rights Law, 1978.

The local entitles within the active areas must cooperate to identify a groundwater managment authority for the area. The groundwater management authority could be formed by agreement by the local entities (i.e., to be one of the existing local entities), or failing this the State Water Resources Control Board with legislative approval could designate an appropriate groundwater management authority, or a new groundwater management district could be formed. However it is formed, the local groundwater managment authority is to develop a management program for the area and perform the necessary managment functions. The managment program will be subject to evaluation by the State Water Resources Control Board, and the managment functions of the authority will likewise be subject to evaluation, If the State Water Resources Control Board finds the performance of the management authority is not in accordance with the program, then it can seek judicial relief through the state's Attorney General. These procedures were intended to establish local groundwater management authorities so that local control would be exercised over the use of the groundwater basin and its storage space.

The Commission furthermore suggested that the doctrines established in case law should be codified, but also that the doctrine of mutual prescription should not be used to establish quotas to groundwater. Instead the basis for allocation should be "fair and equitalbe apportionment of rights to extract groundwater" but considerable discretion should remain with the court to maintain flexibility in the system of allocation. According to Anne Schneider, the emphasis was put on local authority and flexibility because:[86]

> Experts repeatedly admonished that groundwater basins vary a great deal, that supplemental surface water availability varies a great deal for different basins, that problems affecting basins can differ greatly, and that economic factors can be very different for different basins. These perceptions have been seen as the basis for the argument that each basin's management program

[86] Anne Schneider, "The Impact of San Fernando on the Governor's Commission" in Eleventh Biennial Conference. University of California Water Resources Center, Davis: Water Resources Center, 1977, p. 41.

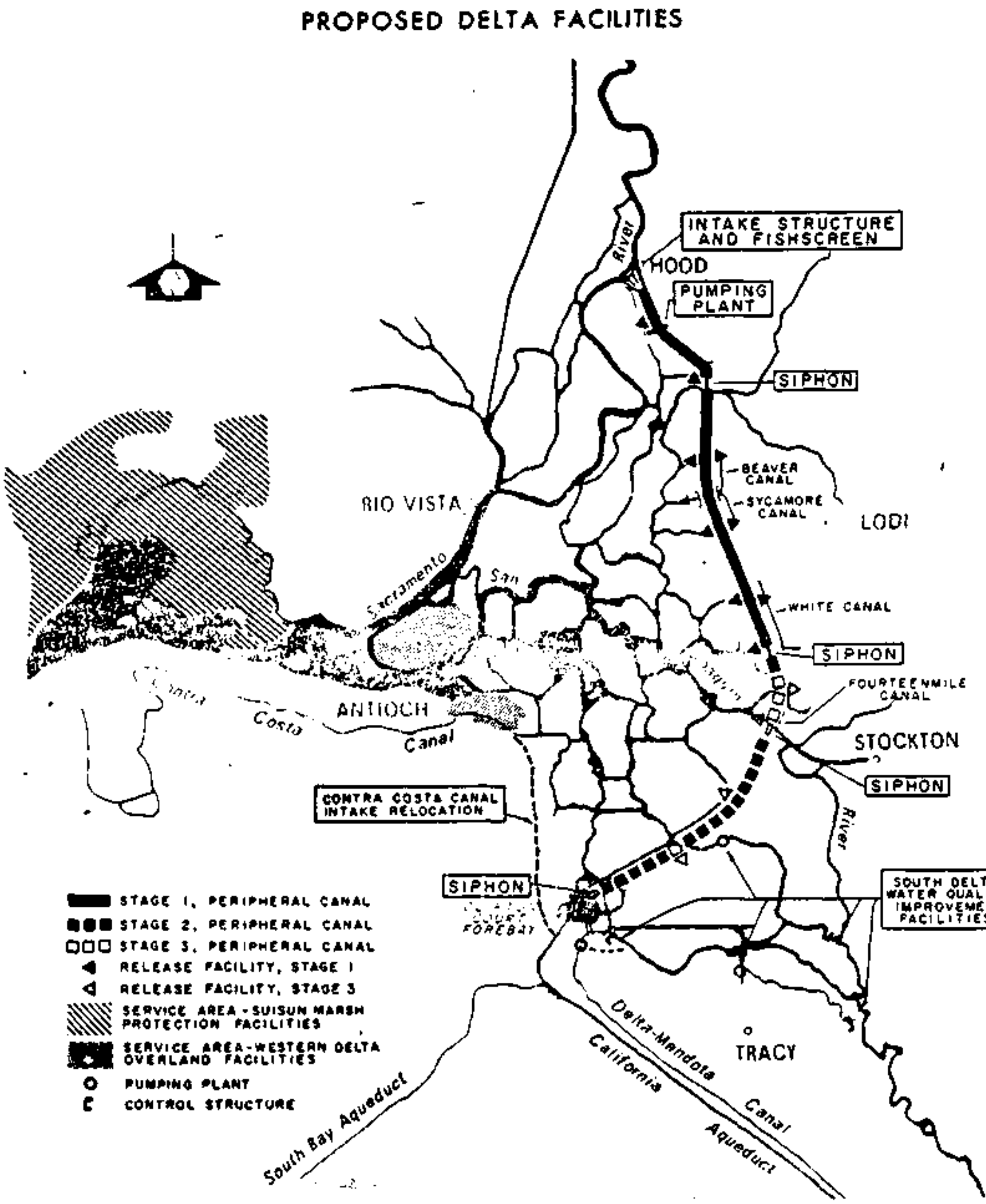
has to be tailored individually to meet the basin pumpers' needs, and that no single approach can be effective in all basins.

Rather than wait for the establishment by the state of Valley-wide groundwater management authorities, local areas may initiate adjudications of local groundwater rights. A prime candidate area is the Fresno area. Current groundwater programs jointly operated by the Fresno Irrigation District and the City of Fresno are being undercut by groundwater pumping in the neighboring Raisin City Water District (see Figure 6-2). Competition over groundwater supplies may drive these parties to court. As in the Los Angeles Basin, once one area is subject to adjudication of groundwater rights, other areas overlying the same basin may quickly follow to adjudicate their rights. In this manner, efficient groundwater may be instituted in the San Joaquin Valley in a piecemeal sequence rather than all at once. Furthermore, this means of groundwater management is local in nature, more in keeping with the State's policy of local governance.

The conclusion of this chapter, and of the entire dissertation, is that efficient groundwater management is unlikely to surface in the San Joaquin Valley under present political and economic conditions. Valley water users fail to see the benefits to be gained from efficient, groundwater management (due to the problem of large numbers) and, hence, have been unwilling to accept the recently suggested groundwater management plans of the Governor's Commission, SB 95, SB 346, or SB 200. Overcoming the present obstacles may require a severe drought which will increase the economic incentives to institute efficient groundwater management, and may allow environmental-regulatory politics to advance this policy issue through the policy process. Nature appears to have more to say about the prospects of efficient groundwater management than does humankind, since it is nature which must provide the triggering event

Figure 6-1

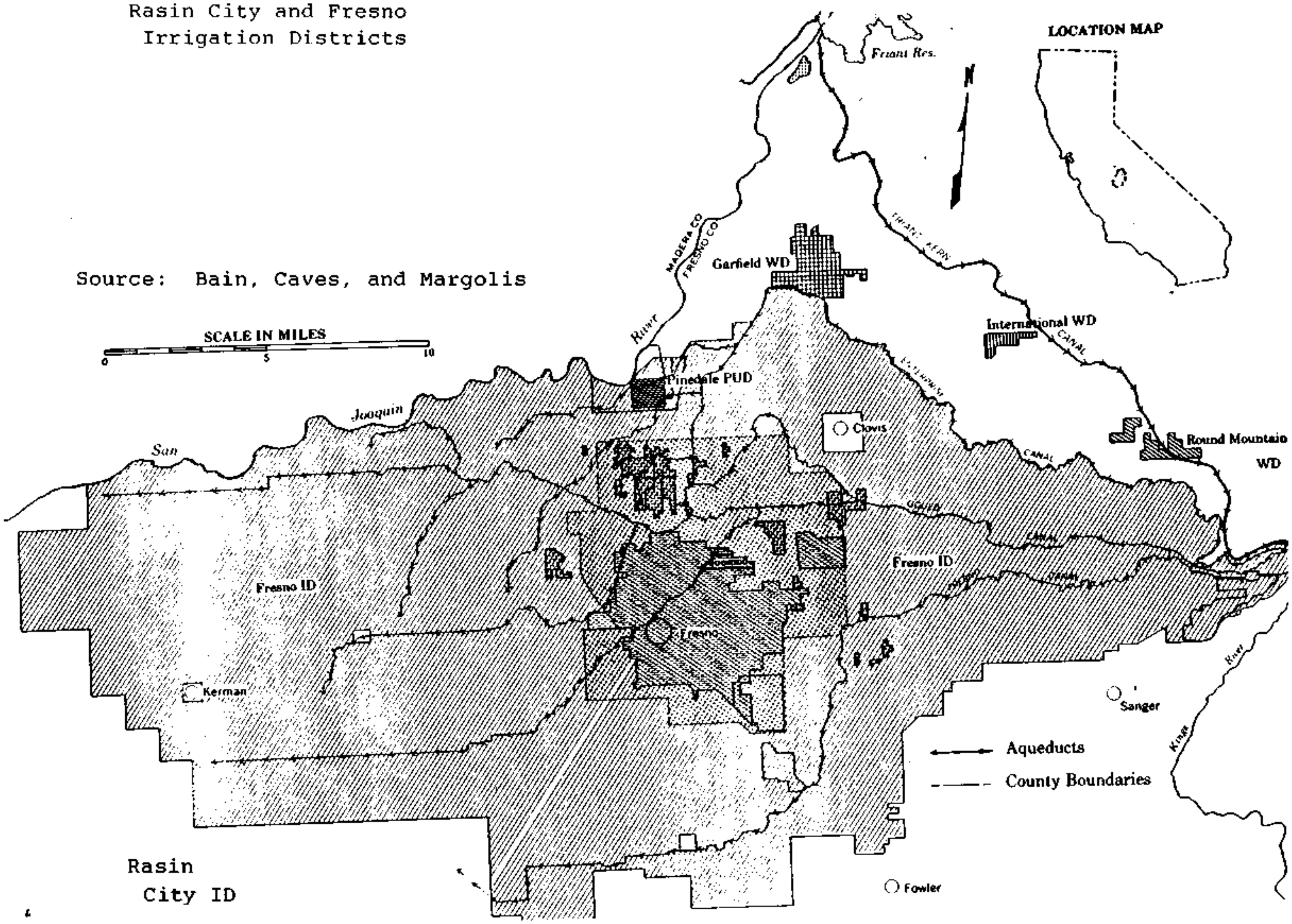
Peripheral Canal



Source: Calif. Dept. of Water Resources, Bulletin 132-79

Rasin City and Fresno
Irrigation Districts

Source: Bain, Caves, and Margolis



Rasin
City ID

Figure 6-2

Table 6-1

POLITICAL AND ECONOMIC CHARACTERISTICS OF WATER DISTRICTS

District Type	California Water Districts Water Storage Districts	Irrigation District
Voting System	property qualification	one person one vote
Farm Size	large	small
Owner Residency	non-resident	resident
Elections	generally noncontested	competitive
Voter Turnout	low	high
Financial Behavior	erratic	stable
Source of Operating Funds	incurring debt	current revenue

Source: Goodman, Sullivan, and DeYoung

CHAPTER SEVEN

SUMMARY AND CONCLUSION

I. Modifying the Common Property Rights to Groundwater

This dissertation has looked at the economic and institutional conditions under which groundwater is used in the state of California. A system to share and allocate must be instituted for all economic resources. Such systems are made more complicated if the resource has a fugitive nature as is the case for a common pool resource such as groundwater. Under the state's Correlative Rights Doctrine, the allocation system is one of first-come-first-served, or what is called the Rule of Capture. Private property rights -- the rights to use, exclude others from use, and transfer to others -- are established only after the individual reduces groundwater to possession, or captures from the basin a unit of the groundwater resource; whereas common property rights apply to groundwater which remains in the basin.

The Correlative Rights Doctrine provides groundwater users with incentives that result in inefficient use of groundwater and in serious conditions of overdraft. Each individual in the community of groundwater users must make extraction decisions ignoring the social costs of these decisions. The cumulative result of these decisions is a lowering of the groundwater table and a raising of groundwater extraction costs at a rate faster than the profit maximizing rate for the community as a whole (or for any individual in the community). The lost profit opportunities from the cumulative result of individually-made decisions provides an incentive for collective action which would grant to the community some means of obtaining efficient use of groundwater.

California Supreme Court Chief Justice Shaw, who authored the 1903 decision in Katz v. Walkinshaw establishing the Correlative Rights Doctrine, recognized the common property nature of the law and the problems of use and management which would eventually result as total use or demand upon groundwater exceeded the supply. Consequently, the Correlative Rights Doctrine includes provisions for its modification. Groundwater users, viewed as members of a community, can petition the court to establish more exclusive rights to groundwater once the basin becomes overdrafted, and if such overdraft begins to adversely affect the welfare of the community. Some groundwater users, in particular parts of the state, have opted to modify the Correlative Rights Doctrine, whereas others, despite the detrimental welfare effects of allowing overdraft to continue, have refused to do the same. The main purpose of this dissertation, and its contribution to the literature on the subject, is an analysis of why the Correlative Rights Doctrine has been modified in some areas but not in others.

Past groundwater right adjudications have resulted in the curtailment, by a "just and fair proportion," of the amount of groundwater which each groundwater user can extract from an overdrafted basin. Whenever the amounts pumped from an acquifer were in excess of the constant annual supply, or safe yield, the right to extract groundwater in total was curtailed to the safe yield, and all individual users shared equally in this curtailment. This procedure establishes quotas for groundwater extraction, which create and add the characteristic of exclusion to property rights in groundwater. In that most adjudications also allow for transfer of the adjudicated rights, the adjudications allow for efficient management of groundwater.

Whenever an individual feels his rights to groundwater are being abused by others, he may petition the court to protect his rights. Court administered management of acquifers has been limited to establishing limits beyond which pumping may not preceed. This management technique inflicts costs upon groundwater users due to decreased availability of groundwater today, but it also benefits groundwater users because of lowered extraction costs in the future. Accepting court administered management is a collective decision. If such management improves the collective welfare of groundwater users, meaning the benefits outweigh the costs, then adjudication of groundwater rights is a collectively rational decision. Many groundwater basins, found predominantly in the southern portion of the state, have made the decision to institute efficient groundwater managment through adjudication.

Adjudication of groundwater rights, and subsequent court administration, has been the main technique used to modify of the Correlative Rights Doctrine. Other modifications have been made: (1) the City of Los Angeles has established exclusive ownership over the groundwaters of the San Fernando Valley; (2) the Orange County Water District has limited access to, and use of, the groundwaters of the Orange County Basin by use of the district's taxing and spending powers; and (3) despite severe overdraft problems, the groundwater users of the San Joaquin Valley have decided not to modify the Correlative Rights Doctrine but to suffer the consequences of using groundwater under common property rights.

The City of Los Angeles is the state's largest single groundwater owner. By extending its pueblo rights to the groundwaters of the San Fernando Basin, by annexing the land overlying this basin, and by purchasing the lands in the Owens Valley which overlie that Valley's groundwater basin, the City of Los Angeles has established exclusive control over vast quantities of groundwater. On the South Coast Basin, adjudication of groundwater rights has allowed the efficient management of groundwater in the West Basin, Central Basin, and Main San Gabriel Basin along the San Gabriel River; and also in the Orange County Basin and Chino Basin located along the Santa Ana River. In the San Joaquin Valley, which overlies the state's largest groundwater basin, agricultural users of groundwater have repeatedly relied upon surface water imports to solve reoccurring groundwater overdraft problems. Despite the success of establishing exclusive rights to groundwater in other parts of the state, groundwater users in the San Joaquin Valley have maintained their common property rights to groundwater. Therefore, the state of California supports two forms of groundwater management policies -- one characterized by collective management and the other characterized by independent, private decisions.

This dissertation has shown that rent-seeking behavior of the state's water users has created two different property rights institutions governing groundwater use. One system continues the common property rights of the Correlative Rights Doctrine, while the other has modified the Correlative Rights Doctrine by establishing exclusive rights to groundwater. In those areas where groundwater rights were adjudicated, or exclusion was otherwise obtained, groundwater was the cheaper of two sources of additional water, and hence accrued a rent to its owners. Rent-seeking behavior led these groundwater users to protect their rights to groundwater, or to protect the rent-earning capacity of the groundwater resource. However, in the San Joaquin Valley, groundwater is the more expensive of two alternative sources of water, and hence, rent-seeking efforts are directed away from groundwater protection and towards obtaining more surface water, since the latter is the cheaper source of water and earns rent to those who employ it. Groundwater management is motivated by the opportunity to accrue rent from groundwater use. Without the necessary conditions for rent to accrue (i.e. that groundwater be the cheaper of two alternative sources of water), groundwater management (a type of rent-seeking behavior) will not be instituted.

II. Application of Ostrom's "A Theory for Institutional Analysis of Common Pool Problems" to Groundwater Management in California

II. A. Managing Common Pool Resources

Common property problems arise from the use of common pool resources whenever the following conditions are present: (1) ownership of the resource is held in common, (2) a large number of users have independent rights to the use of the resource, (3) no one user can control the activities of other users or, conversely, voluntary agreement or willing consent of every user is required in joint action involving the community of users, and (4) total use or demand upon the resource exceeds the supply.[1] Solution to groundwater's common property problem, specifically the severe conditions of overdraft that have plagued various groundwater basins in the state of California, requires either some means of eliminating common ownership or reducing either the number of users or their independent right to use groundwater.

The dominant form of the collective action to bring about this solution has been an adjudication of groundwater rights, which eliminates common ownership of groundwater by establishing for every groundwater user an exclusive quota of groundwater in relation to his past historical use. However, other means have been used. Los Angeles reduced the number of users to one, and the Orange Coast Basin groundwater users communicate the social cost of groundwater extraction through the use of extraction taxes. These means of managing groundwater will be summarized below.

II. B. Management by Single Ownership -- the City of Los Angeles

Groundwater's importance to the City of Los Angeles should not be underestimated. Not only is the water supply system of the City of Los Angeles dominated by groundwater, but the location of the City was determined by the Los Angeles River whose source is the aquifer underlying the San Fernando Valley. The pattern of growth and the shape of the City were

[1] Vincent Ostrom and Elinor Ostrom, "A Theory for Institutional Analysis of Common Pool Problems," in Managing the Commons edited by Garrett Hardin and John Baden, San Francisco: W.H. Freeman and Co., 1977.

determined by the City's desire to control the flow of the Los Angeles River through management of the underground reservoir beneath the floor of the San Fernando Valley. The groundwater management policy of the City of Los Angeles can be characterized as management by land ownership.

The Los Angeles Aqueduct transfuses the City of Los Angeles with water from the Owens Valley. When the aqueduct was first built, the San Fernando Valley was used to store the delivered water so that it could be collected through the Los Angeles River. When the City needed more water, it turned to the groundwater resources of the Owens Valley. The Los Angeles Aqueduct allows the City to draw upon Owens Valley groundwater in times of water shortage, and in times of plenty, surplus water is diverted to the aquifer for use during the next dry cycle. Such a groundwater management program is possible because only the City owns the groundwaters of the two valleys; no one is able to compete with it for use of these groundwater supplies.

Becoming a single owner establishes exclusive rights to groundwater and hence the potential for an efficient outcome exists. The City of Los Angeles established exclusive control over groundwater in both the San Fernando Basin and in the Owens Valley Basin. This allowed the City to eliminate the adverse interaction or joint costs that arise from having many users independently pursuing extraction decisions. By extending its pueblo rights to the groundwater of the San Fernando Basin, by annexing to the City the lands overlying the basin, and by purchasing the lands overlying the Owens Valley Basin, the City established exclusive property rights to groundwater.

Pueblo rights to water are tantamount to private rights in that they carry the ability to use, to exclude others from use, and to transfer to others.[2] Since the City of Los Angeles was

[2] This latter right was subject to provisions in the city charter which required a two-thirds majority vote to sale any of the city's water.

able to get its pueblo rights applied to the groundwater of the San Fernando Valley, the City, in effect, was the exclusive owner of the groundwater. Enforcement of these rights was accomplished by annexation of most of the San Fernando Valley, and by suing those municipalities in the San Fernando Valley who encroached upon the groundwaters of the basin. Enforcement and maintenance of its exclusive rights to groundwater gave the City near monopoly control over the quantity of groundwater extracted from the basin. (Despite this monopoly position, the city did not adopt monopoly pricing of groundwater[3]).

By separate means -- pueblo rights applied to the San Fernando Basin and ownership of lands overlying the Owens Valley Basin — the City of Los Angeles gained exclusive control over two groundwater basins. They connected these two basins with the Los Angeles Aqueduct. This exclusive control in both basins eliminated the social costs that ordinarily are found in groundwater basins exploited by many producers with common property rights to the groundwater. Instead, the two basins were operated as Joint storage facilities so that the City has access to stored groundwater during periods of drought, and during periods of surplus, it can store water for later use. The result has been low-cost water for the City of Los Angeles, extremely low costs when compared to the cost of alternative water which is available from the Metropolitan Water District.

If the City of Los Angeles had not established exclusive ownership over groundwater, or if some other means of efficient management were not instituted, then the cost of extracting groundwater from the San Fernando Valley would have been much higher than it is, perhaps as

[3] For a description of Los Angeles' water pricing policy, see Jack Hirshleifer, James C. DeHaven, and Jerome W. Milliman. Water Supply: Economics, Technology, and Policy. Chicago: University of Chicago Press, 1960.

high as the cost of water from the Metropolitan Water District.[4] The policy of management by ownership has kept the water costs to the City much lower than the alternatives -- either water from the Metropolitan Water District, or from the California Aqueduct. Though it would be stretching the point to say that all of the City's management-by-ownership policy actions were rent-seeking behaviors, nevertheless the "second barrel" of the Los Angeles Aqueduct and City of Los Angeles v. City of San Fernando[5] were actions taken by the City to secure low cost groundwater and avoid paying a higher price for water from alternative sources (i.e. rent-seeking behavior).

II. C. Groundwater Management on the South Coastal Plain

The reduction of joint costs, through the adoption of exclusive property rights or some similar institutional arrangement which takes social costs into consideration, represents a potential benefit which encourages collective action. The potential benefit, according to Ostrom, "can be conceptualized as a potential political (or community) surplus available for capture by those who develop institutional arrangement to undertake joint management and development of the common pool resource."[6] However, capture of this surplus is often a costly activity. Nevertheless, if the costs are less than the benefits from collective action, i.e. a political surplus exists, then collective action should be forthcoming to capture that surplus. Political surpluses appear to have existed in the groundwater basins of the South Coastal Plain. The pattern followed in each basin in the institutionalizing of collective action was (1)

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[4] The annual dollar benefit to the City of its groundwater management program can be estimated as the product of the difference between the cost of groundwater and the cost of Metropolitan Water District water (the next best alternative source) and the quantity of water groundwater used. This return, though not the motivating force behind the City's drive to becoming a single owner of groundwater, is its reward for having done so.

[5] City of Los Angeles v. City of San Fernando 123 C. 3d 1, (1975).

[6] Ostrom and Ostrom, p. 160.

establishment of a groundwater users association, (2) the adjudication of groundwater rights which granted exclusive rights to those groundwater users with a long (5-year) history of use (I.e. adverse possession), (3) establishment of control over extraction either by injunction against pumping greater than a given quota of groundwater or by the charging of a per-unit tax upon groundwater extraction (with the revenue from the tax used to purchase surface water to replenish the extracted groundwater) and (4) annexation of the basin to the Metropolitan Water District to secure additional supplies of water.

Rapid rates of population and economic growth raised the value of water on the South Coastal Plain. The initial consequence was greater extraction of groundwater and rapidly rising groundwater costs. Realizing groundwater supplies were insufficient to support continued growth, water users formed the Metropolitan Water District to Import water from the Colorado River. Because Metropolitan Water District water was more expensive than groundwater, little incentive initially existed to use the imported surface water. To encourage efficient management of groundwater resources, the Metropolitan Water District required areas desiring annexation to overlie a whole groundwater basin. Such a policy would have assisted in the conjunctive use of surface and groundwater supplies, but other financial and organizational considerations led to abandonment of this policy.

In the meantime, continued growth and encroachment on the groundwater supplies of the South Coastal Plain led to a worsening of overdraft. Groundwater users, to protect rents available from groundwater use, sought to establish exclusive rights to groundwater. Exclusive rights were established by claim of prescriptive rights to groundwater based on the principle of adverse possession. Extractions from most basins is limited to the safe-yield of the basin, or if extractions exceed the safe-yield, replenishment water is purchased. Despite the adjudication of groundwater rights, growth continued but it was based upon increased use of Metropolitan Water District, not on groundwater. As the price of Metropolitan Water

District water has risen, and the extraction costs of groundwater have stabilized, the rents that accrue to groundwater users have increased.

Adjudication of production rights establishes private property rights to the safe yield of the basin, but property rights to the stock of groundwater in the basin is retained by the groundwater management agency which is usually a local water district. Preventing entry into the basin by new pumpers, and limiting the present pumpers to the safe yield of the basin, assures the future availability of groundwater and minimizes pumping costs by maintaining the level of the water table. The private property rights to the safe yield are usually transferable through an exchange pool. The supply of production rights comes mainly from small, agricultural users of the groundwater who are anxious to sell their rights in exchange for cash. The demand for production rights is due to the large-volume, urban uses of water which allow the purchase the production rights because it saves water users the expense of meeting all their needs by using imported surface water.

The Orange County Water District has a unique groundwater management program, but it nonetheless conforms to the above rent-seeking behavior. A replenishment assessment equalizes the cost of groundwater with the cost of imported surface supplies, thus eliminating any incentive for new pumpers to enter the basin. The Basin Equity Assessment program was initiated which transfers the rents from groundwater to the large water users of the basin in the form of a surface water price subsidy. The use of replenishment water is a key component of all groundwater management plans, but particularly so in the Orange County Water District which uses the basin to absorb and disperse water throughout the district.

In unmanaged groundwater basins, the groundwater is the common property of anyone who has access to it through a well. If rents exist from the use of groundwater, then groundwater users have an incentive to protect those rents from being tapped by others. The protection of rents from the encroachment of others, and likewise, the capture of rents by oneself, requires that controls be placed upon who can use the groundwater and how much they can use. Economic incentives caused by rents, should stimulate a political response which affects the management of groundwater (e.g. adjudication). However, not all overdrafted areas have pursued groundwater managment. The reason for this difference in behavior is that in those unmanaged areas with high costs of overfraft, no rent accures to the users of groundwater, so no incentive for managment exists.

II. D. Groundwater Use in the San Joaquin Valley

Using an optimal control model, this dissertation has shown that there is a substantial increase in net income available to San Joaquin Valley groundwater users from the adoption of efficient groundwater management. For 28 "detailed analysis units" the net income from groundwater use under two alternative property right systems were compared. The two property right systems were common property rights and private property rights, the latter being the type of rights that would be established by adjudication and that would result in efficient management. These net incomes are measured by taking the net incomes in future periods over a 40 year horizon, discounting these furure incomes at a 4 percent interest rate, and adding these discounted future incomes to get the present value from groundwater use under each set of property rights. The present value from groundwater use under optimal control (i.e. private property rights) is greater than the present value from groundwater use under common property rights. The difference between the two is claimed to be an economic incentive to adjudicate groundwater rights in the San Joaquin Valley. This incentive, net of adjudication costs, is $ 1.29 at a 4 percent discount rate.

If no rents exist then there will be no management of groundwater, or if the economic incentives to institute management are outweighed by political or other considerations, then there will be no management. Although a large increase in net Income is available to the groundwater users of the San Joaquin Valley, a number of factors constrain their attainment of this income. Among the most important of these factors are the large numbers of water districts already existing in the Valley, the water pricing policies of these districts, and the use of distributive politics to secure surface water imports to temporarily alleviate overdraft problems.

Because there are so many water districts in the San Joaquin Valley, none designed for groundwater management, and because their boundaries are too small to encompass more than a portion of the individuals affected by the problems of common property rights to groundwater, no one district is likely to perceive a benefit from instituting groundwater management that is greater than the costs of initiating the collective action. The public good nature of the benefits from efficient management of groundwater disperse the benefits in proportion to the quantity of groundwater extracted, but the economic, legal, and time costs of initiating such action will fall upon a relative few.

The water pricing policy of water districts in the San Joaquin Valley is characterized by inefficiency. Long-term contracts which do not allow the price of water to rise to reflect its relative scarcity is only one source of inefficiency. Since Bureau prices are subsidized, the difference between the efficient price of water and that actually paid is even greater. Advantages which the efficient pricing of groundwater brings to the overall agricultural water-use situation are lost if surface water is not also priced efficiently. The history of water prices in the Valley provides no examples of surface water price flexibility, and hence no encouragement for the establishment of efficient groundwater management.

Subsidized surface water prices have made surface water cheaper than groundwater. Use of the cheaper of the two substitute types of water gives rise to a rent which encourages further use of the cheaper water. The response to groundwater overdraft by farmers in the

San Joaquin Valley has been towards increasing the availability of surface water.[7] This rent-seeking behavior will continue to dominate water politics in the San Joaquin Valley as long as the price differential between surface water and groundwater remains. Only if additional surface water is made available at its marginal cost, and if the marginal cost is greater than the cost of groundwater extraction, will water users' rent-seeking behavior be turned towards efficient management of groundwater. Because the pricing policy of water districts subsidizes surface water prices below groundwater prices, the opportunity to increase rent lies with those water users who can increase their usage of surface water. Surface water augmentation has been the policy response of the Valley's water districts to the problem of groundwater overdraft. This response is because of rent-seeking behavior by the water users in the Valley.

The constraints to efficient groundwater management -- the large number of water districts, water pricing policies of the districts, and the use of distributive politics to secure additional surface water imports as a solution to groundwater overdraft problems-- are not independent of each other. This independence, nevertheless, may work to the advantage of those who seek efficient management of groundwater. A prolonged drought of crisis proportions may spark environmental-regulatory politics to the forefront of California water politics, replacing distributive politics as the means of formulating policy. A policy proposal that correctly tailors "specific incentives" to account for the variability across the numerous groundwater users of the Valley may succeed in gaining sufficient momentum to pass through

[7] The traditional response to groundwater overdraft problems in the Valley has been surface water augmentation. Repeated shortages of water led first the local public water districts, then the U. S. Bureau of Reclamation, and finally the California Department of Water Resources to build surface water storage and transport facilities. Whenever groundwater costs would rise to threaten the profitability of irrigated agriculture, Valley farmers would initiate collective action to increase the amount of available surface water. Because these supplies of surface water were provided at subsidized prices, surface water was substituted for groundwater, and conditions of groundwater overdraft would ameliorate. However, cheap water would lead to more water being demanded, and conditions of severe overdraft would return. Because surface water is cheaper than groundwater, efficient groundwater management will not accrue rent to the groundwater users of the San Joaquin Valley.

the policy process. The establishment of private property rights to groundwater, as is the design of adjudications based upon prescriptive rights, may be Just such a policy.

The main conclusion of this dissertation is that efficient groundwater management is unlikely to surface in the San Joaquin Valley under present political and economic conditions. Valley water users fall to see the benefits to be gained from efficient groundwater management and have been unwilling to accept recently suggested groundwater management plans (e.g. those of the Governor's Commission to Review California's Water Rights[8]). Evidently, the cost of institutionalizing this form of collective action are substantial, apparently greater than the benefits, since the common property problems In the Valley remain unsolved.[9]

III. Conclusion

It is a price differential between the cost of alternative waters that allows for the creation of rent -- rent which gives the incentive to pursue capture of and control over the cheaper of the two alternatives types of water. In environments characterized by conditions of severe overdraft, groundwater users on the South Coast Basin pursued activities to protect rents to groundwater, whereas groundwater users in the San Joaquin Valley pursued activities to increase rents from surface water use. The difference between rent (which can be captured by the creation of exclusive shares to a fixed resource) and income (which results from improved techniques of use) is fundamental to the existence of or lack of an incentive which

[8] See Governor's Commission to Review California Water Rights Law, Groundwater Rights in California. Staff Paper No. 2 by Anne Schneider, Sacramento: Governor's Commission to Review California Water Rights Law, 1978.

[9] Since individuals in the San Joaquin Valley have access to a wide variety of institutional arrangements for collective action, then it must be that their common pool problem remains unsolved because the benefits of collective action do not exceed the costs of collective action for any presently available decision rule. Adjudication of groundwater rights is another form of collective action, but it avoids many of the organizational costs suggested by the inertia of existing water districts.

sparks human activity. The increased income that will be due to efficient groundwater management, when groundwater is the more expensive of two alternative sources of water, is an income earned in exchange for management efforts and is not an income that represents a surplus to motivate rent-seeking behavior.

As long as surface water costs remain below groundwater costs, income benefits for the San Joaquin Valley farmers from the adoption of efficient groundwater management are not rents but a management-earned income spread in proportion to groundwater use across nearly every water user in the San Joaquin Valley. The non-specific benefits of efficient management creates income which pales in comparison to the costs borne by any group of users (e.g. water districts) who may initiate Valley-wide management institutions. However, on the South Coast Basin, specific groundwater users were able to assure continued and substantial rents by adjudication of groundwater rights. These rents were specific to those who could prove adverse possession, and the benefits were perceived to be greater than the costs of continued common property rights to groundwater. Adjudication of groundwater rights and efficient groundwater managment exist in one section of the state and not the other because in that one section, rent was earned from adjudication of rights. Institutions which subsidize surface water prices to below the cost of groundwater extraction deny the existence of rents to be earned from adjudication of rights, and hence eliminate the incentive to institute efficient groundwater management.

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