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Managing Groundwater Quality and Quantity in the San Joaquin Valley, California: Integrated Strategies for Protecting Groundwater in Arid Regions

Randolph B. Flay* and T.N. Narasimhan

Earth Sciences Division

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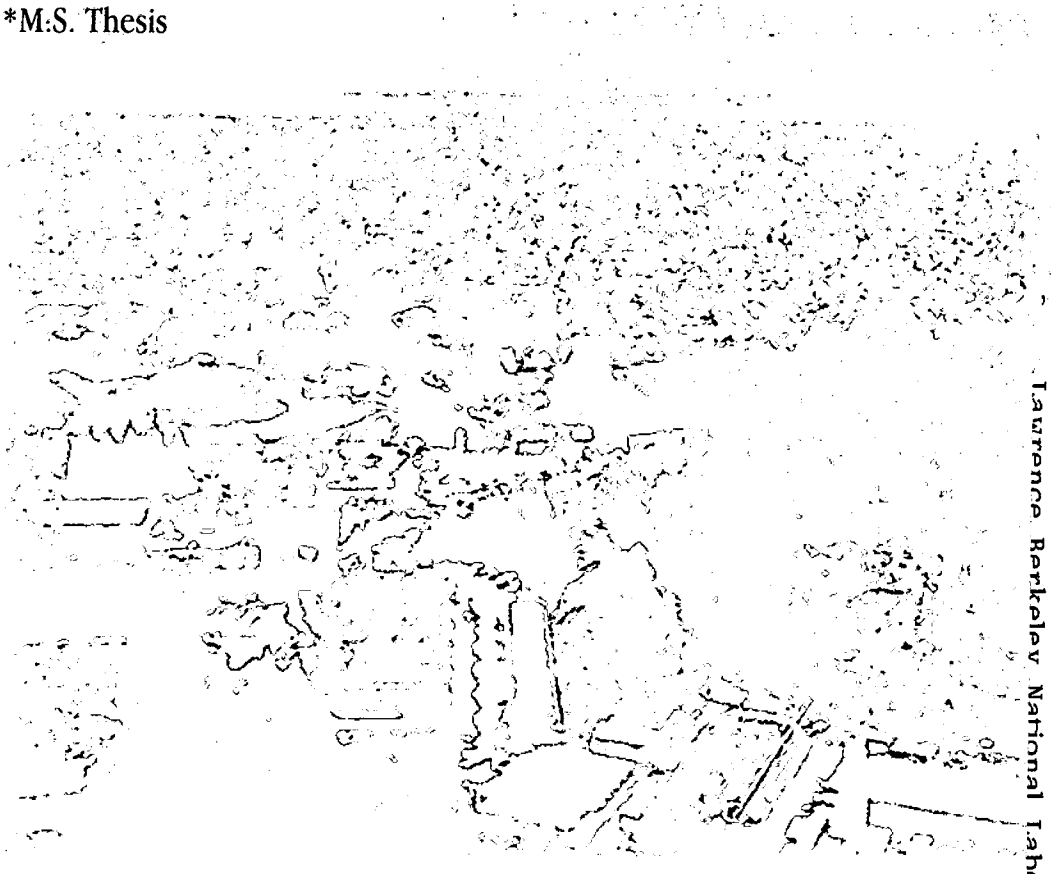
*M.S. Thesis



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Managing Groundwater Quality and Quantity in the San Joaquin Valley, California: Integrated Strategies for Protecting Groundwater in Arid Regions

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Abstract

Managing Groundwater Quality and Quantity in the San Joaquin Valley, California: Integrated Strategies for Protecting Groundwater in Arid Regions

by

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The following quote from the case of Cline v. American Aggregates,[1] which came before the Supreme Court of Ohio in 1984, reasserts the fundamental need to apply improvements in groundwater science to our institutional and legal arrangements that manage it. The court stated: "Finally, a primary goal of water law should be that the legal system conforms to hydrologic fact. Scientific knowledge in the field of hydrology has advanced in the past decade to the point that water tables and sources are more readily discoverable. This knowledge can establish the cause and effect relationship of the tapping of underground water to the existing water level. Thus, liability can now be fairly adjudicated with these advances which were sorely lacking when this court decided Frazier more than a century ago." While California has since 1903 not observed the English Rule of Capture with regards to property rights in groundwater (which was overturned in Ohio by the case above), there is a significant need to move beyond the current system of management which has done little to ensure certainty in groundwater rights and protect groundwater quantity and quality for the long-term. Given the recent effort undertaken to examine the authority of the State Water Resources Control Board (SWRCB) to control

[1] *Cline v. American Aggregates Corporation* (1984). 15 Ohio St. 3d 384.

groundwater,[2] this is perhaps a suitable occasion to examine how far California has come since the Report of the Governor's Commission to Review Water Law in California some two decades ago recommended to the state legislature several steps for California to incorporate advances in science into our systems of management.[3]

The management of groundwater in the western United States has evolved greatly over the past 70 years. States such as Arizona, New Mexico, and Texas have put in place systems that impart expanded regulatory and management activities on the part of state government. In most states, except Texas, common law traditions recognizing the English Rule have been replaced by the correlative and appropriation rights doctrines. These actions have been in response to conditions of overdraft, subsidence, and, in some cases, contamination from nitrates and other contaminants of anthropogenic origin. More recently, interstate compacts and endangered species concerns have required the accurate quantification of all water resources in basins, leading to the quantification of rights and permitting programs.

California remains one of a handful of states without a formal administrative role in the protection of groundwater. At several times during the 1900s, arguments were presented to the California State Legislature and the SWRCB recommending a more compressive system of groundwater administration.[4] However, except for limited circumstances where

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[2] Sax, J. L. (2002). Review Of The Laws Establishing The SWRCB's Permitting Authority Over Appropriations Of Groundwater Classified As Subterranean Streams And The SWRCB's Implementation Of Those Laws. Sacramento: State Water Resources Control Board.

[3] Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.

[4] Holsinger, H. and Department of Water Resources (1956). Required ground-water legislation: Department of Water Resources.
California Legislature. Assembly Interim Committee on Water (1962). Ground Water Problems in California : A Report of the Assembly Interim Committee on Water to the California Legislature. Sacramento, CA: Assembly of the State of California.
Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.

basins have been adjudicated or statutorily created groundwater management districts exist, the vast majority of groundwater extraction is unquantified. In overdrafted regions, decisions over allocation are largely left to the costly and uncertain processes of adjudication, while issues of protection and management are left to the motivation of local districts with few venues for basin-scale planning. Reliance on existing institutions has not been successful in reducing the uncertainty associated with groundwater rights.[5] Further, it has failed throughout many regions of the state, in particular the San Joaquin Valley, to mitigate conditions of overdraft, salinization, and trace element contamination, all of which are intimately connected to the patterns of groundwater use.[6]

This thesis examines the approaches of Arizona, Colorado, Nebraska, New Mexico, and Texas to the management of groundwater to seek solutions that are compatible with California's hydrologic and legal settings. These states have taken steps to integrate recent scientific knowledge of groundwater flow and chemistry into their legal mechanisms of allocation and protection.[7] Recent advances in understanding the importance of groundwater in regional flow and chemistry must be reconciled with the laws and institutions that dictate its allocation and management. Optimal and sustainable groundwater use requires the installation of institutions that manage groundwater at the

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[5] *United States of America v. State Water Resources Control Board* (1986). 182 Cal.App.3d 82.
City of Barstow v. Mojave Water Agency (2000). 23 Cal. 4th 1224.
[6] San Joaquin Valley Drainage Implementation Program (1998). Drainage Management in the San Joaquin Valley: A Status Report. Sacramento, CA: The Program.
[7] Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688.
Nebraska Natural Resources Commission and Nebraska State Water Planning and Review Process (1986). Integrated management of surface water and groundwater. Lincoln, NE: State Water Planning and Review Process Nebraska Natural Resources Commission.
Mossman, S. D. (1996). ""Whiskey is for Drinkin' but Water is for Fightin' About': A First-hand Account of Nebraska's Integrated Management of Ground and Surface Water Debate and the Passage of L.B. 108"." Creighton Law Review 30 Creighton L. Rev. 67.

temporal and spatial scales at which it interacts with surface water and the land.[8] The San Joaquin Valley is an example of where the current management system lacks the capacity to manage groundwater optimally at large scale, cognizant of groundwater-surface water connections. Utilization of the Institutional Analysis and Development (IAD) framework[9] has helped discern where existing approaches to groundwater management (e.g. Assembly Bill 3030[10] and adjudication) are not appropriate in large, arid basins with diverse water uses.

Largely over the past two decades, Arizona, Colorado, Nebraska, New Mexico, and Texas have each devised unique programs for managing groundwater. These states have sought to cultivate institutions that manage by hydrologic regions, as in the case of Nebraska where Natural Resource Districts largely based on hydrologic boundaries have become the unit for implementing the state's groundwater policy. Although these programs understandably differ,[11] they have several common characteristics, including: (1) clear mechanisms of groundwater allocation and dispute resolution, (2) long-term planning and

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[8] Blomquist, W. A. (1991). Coordinating water resources in the federal system: the groundwater-surface water connection. Washington, D.C.: U.S. Advisory Commission on Intergovernmental Relations.
Toth, J. (1995). "Hydraulic Continuity in Large Sedimentary Basins." Hydrogeology Journal 3(4): 4-16.
Narasimhan, T. N. and N. W. T. Quinn (1996). Agriculture, Irrigation, and Drainage, on the West Side of the San Joaquin Valley, California: Unified Perspective on Hydrogeology, Geochemistry, and Management.: LBL-38498. Berkeley: Lawrence Berkeley Laboratory, University of California.
Toth, J. (1999). "Groundwater as a geologic agent: An overview of the causes, processes, and manifestations." Hydrogeology Journal 1999(7): 1-14.
Winter, T. C., et al. (1999). Ground Water and Surface Water: A Single Resource: Circular 1139. Denver, CO: U.S. Geological Survey.
Sophecleous, M. and S. P. Perkins (2000). "Methodology and application of combined watershed and groundwater models in Kansas." Hydrology 236: 185-201.
Toth, J. (2000). "The key to improvements in aquifer protection: Analytical hydrogeology." Acta Geologica Hungarica 43(2): 145-155.

[9] Schlager, E. and W. Blomquist (1998). Resolving Common Pool Resource Dilemmas and Heterogeneities Among Resource Users. Crossing Boundaries, The Seventh Annual Conference of the International Association for the Study of Common Property, Vancouver, British Columbia. In this thesis the IAD framework has been useful for identifying two central problems, (1) the discord between the scale of physical processes and groundwater management jurisdiction and (2) the lack of hierarchy in the management spectrum to coordinate and delegate authority to address issues at various scales.

[10] Assembly Bill 3030 (AB 3030) is codified as § 10750 et seq. of the California Water Code (CWC).

[11] Texas still observes the English Rule of Absolute Ownership of groundwater following the decision in *Charles C. Motl v. R. W. Boyd* (1926). 116 Tex. 82; 286 S.W. 458; 1926 Tex. LEXIS 96. This decision was reaffirmed in *Bart Sipriano et al. v. Great Spring Waters of America* (1999). 1 S.W.3d 75; 1999 Tex. LEXIS 49; 42 Tex. Sup. J. 629.

goal setting, (3) clear jurisdiction in administration of groundwater, (4) comprehensive monitoring, (5) state oversight with varying degrees of local implementation, and, in some instances, (6) ambient groundwater quality protection programs. Most of these features are absent from California's system of groundwater allocation and quality protection.

A comparison of these states has yielded several interesting findings suggestive of potential action in California. First, given California's long history with water districts at the forefront of water allocation and protection, water districts must be the basis for achieving this optimal outcome. Currently 157 types of water districts exist in California, often with conflicting goals, boundaries, and authority. Second, a comprehensive monitoring and accounting program needs to take shape. The passage of AB 599 this past year to study the potential for increased coordination in groundwater monitoring is a positive step, but substantive changes are necessary. Third, there should be a substantive groundwater planning component to these districts. The establishment of Basin Management Objectives (BMOs),[12] as has occurred in a few areas in California, would further long-term planning goals. Unfortunately, many Assembly Bill 3030 (AB 3030) groundwater management plans often lack substantive components. Substantive groundwater plans could be used to integrate groundwater into the Regional SWRCBs' Basin Plans.

SB 1938 (Machado) as amended (May 21, 2002) could foster substantive components in groundwater plans by linking state funding to the inclusion of such components. In order to qualify as a groundwater management plan for the purposes of funding, the bill would require BMOs relating to groundwater level regulation, quality degradation, subsidence, and

[12] For an excellent overview of the Basin Management Plan concept, see Hauge, C. (2002). Groundwater Management. San Joaquin Valley Branch Groundwater Resources Association, Fresno, California.

surface water impacts on groundwater quality and level. It also would require the imposition of a monitoring program sufficient to detect changes in groundwater level and quality.

The Commission wrote in 1978, ". . . California's extensive and extremely valuable groundwater resources are not adequately protected. Except in a few areas, groundwater extraction is not managed to the extent that oil and gas production, timber harvesting, mining, or even surface water diversions are. California's water is usually available to any pumper, public or private, who wants to extract it, regardless of the impact of extraction on neighboring groundwater pumpers or on the general community." Given the array of ideas available for remedying the situation that have been implemented in neighboring states, it appears that California could develop more effective institutions to foster the long-term protection of groundwater quality and quantity.

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List of Abbreviations and Acronyms

Abbreviation/Term	Definition
AB 3030	Assembly Bill 3030, amended the California Water Code to allow existing agencies to create a groundwater plan.
ADEQ	Arizona Department of Environmental Quality
AF	Acre-feet
AWBA	Arizona Water Banking Authority
BMO	Basin Management Objective
CAGRD	Central Arizona Groundwater Replenishment District
CalEPA	California Environmental Protection Agency
CAWCD	Central Arizona Water Conservation District
CFGC	California Fish and Game Code
CFS	Cubic feet per second
CVP	Central Valley Project
CWA	Clean Water Act
CWC	California Water Code
DWR	Department of Water Resources
DWSAPP	Drinking Water Source Assessment and Protection Program
EAA	Edwards Aquifer Authority
EC	Electrical Conductivity
ESA	Endangered Species Act
EUWD	Edwards Underground Water District
L.B. 108	Legislative Bill 108 (Nebraska)
LSJR	Lower San Joaquin River
MAF	Million Acre-Feet
NPS	Nonpoint source pollution
NRCS	National Resource Conservation Service
NRD	Natural Resource District
OSE	Office of the State Engineer
PTD	Public Trust Doctrine
RCD	Resource Conservation District
SJHR	San Joaquin Hydrologic Region
SJR	San Joaquin River
SJV	San Joaquin Valley
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAES	Texas Agricultural Extension Service
TDS	Total Dissolved Solids (mg/L)
TLHR	Tulare Lake Hydrologic Region
TMDL	Total Maximum Daily Load
TNRCC	Texas Natural Resource Conservation Commission
TWC	Texas Water Commission
TWDB	Texas Water Development Board
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

List of Unit Conversions

Units	Metric Equivalent	US Equivalent
acre	0.404 hectares	43,560 feet^2
acre	4,046,900 4 meters^2	4,840 yards^2
acre	0.004 kilometers^2	0.0016 miles^2
acre-foot	1233 meters^3	one acre filled to a depth of one foot
cubic feet per second	0.028 m^3/sec	
degrees, Celsius	subtract 32 and divide by 1.8 to obtain degrees C (water boils at 100 degrees C, freezes at 0 degrees C)	multiply by 1.8 and add 32 to obtain degrees F degrees, (water boils at 212 degrees F, freezes at 32 degrees F)
foot	30.5 centimeters	12 inches
foot	0.305 meters	0.33 yards
foot	0.000305 kilometers	0.000189 miles, statute
foot^2	929.03 centimeters^2	144 inches^2
foot^2	0.0929 meters^2	0.111 yards^2
foot^3	28.317 liters	7.481 gallons
foot^3	0.0283 meters^3	1,728 inches^3
gallon	3.785 liters	4 quarts, liquid
hectare	10,000 meters^2	2.471 acres
inch	2.54 centimeters	0.083 feet
kilogram	0.001 metric tons	2.205 pounds
kilometer	1,000 meters	0.621 miles, statute
kilometer^2	100 hectares	247.105 acres
kilometer^2	1,000,000 meters^2	0.386 miles^2
liter	1,000 milliliters	1.057 quarts, liquid
meter	100 centimeters	1.094 yards
meter^2	10,000 centimeters^2	1.196 yards^2
meter^3	1,000 liters	1.308 yards^3
mile	1.609 kilometers	5,280 feet or 8 furlongs
mile^2	258.998 hectares	640 acres or 1 section
million acre-feet	1.233 km^3	
pound	454 grams	16 ounces
yard	0.914 meters	3 feet
yard^2	0.836 127 36 meters^2	9 feet^2
yard^3	0.765 meters^3	27 feet^3
yard^3	765 liters	202 gallons

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Chapter I. Introduction

A. Problem Definition

Through powers reserved by the United States Constitution, the states are empowered to develop mechanisms to control and manage water resources.[13] For more than 100 years, legislatures and courts in the western United States have utilized this authority to recognize common law systems of water rights to administer the general distribution of groundwater and to enact regulations to actively manage groundwater quality and quantity. In recent years, most western state legislatures with hydrologic settings similar to California (e.g. Arizona, Colorado, Nebraska, New Mexico, and Texas) have passed laws significantly expanding the role of state government in the administration and management of groundwater.[14] Yet, the California Legislature has not created an effective system of groundwater management that will preserve present and future public interests in groundwater. Inaction has endured despite the recommendations of reports authored by the California Department of Water Resources (DWR),[15] other state and federal agencies,[16] and several public organizations that have called for increased oversight.[17]

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[13] U.S. Constitution, Amendment X. The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people.

[14] Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688.
Patrick, K. L. and K. E. Archer (1994). "A Comparison of State Groundwater Laws." Tulsa Law Journal 30 Tulsa L.J. 123.
Lusk, S. E. H. (1998). "Texas Groundwater: Reconciling the Rule of Capture with Environmental and Community Demands." St. Mary's Law Journal 30 St. Mary's L. J. 305.

[15] Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.
Department of Water Resources (1980). Bulletin 118-80: Ground Water Basins in California: 118-80: State of California.

[16] United States. General Accounting Office (1980). Ground water overdrafting must be controlled : Report to the Congress. Washington, D.C.: U.S. General Accounting Office.
United States. Congress. Senate. Committee on Energy and Natural Resources. Subcommittee on Water and Power (1992). Western Water Policy Review Act of 1991 : hearing before the Subcommittee on Water and Power of the Committee on Energy and Natural Resources, United States Senate, One Hundred Second Congress, first session, on S. 1228 ... September 19, 1991. Washington, D.C.: U.S. Government Printing Office.

The need for such legislation is backed by clear evidence of the importance of groundwater to California, such as the volume consumed (35 percent of total, 60 percent in dry years), its geographic distribution (found in many areas of the state where surface water resources are limited), and the degree to which it is protected from contamination (very difficult or even impossible to remediate once contaminated). California's approach to resolving these issues thus far has been for the state to take a decentralized and hands-off approach to management, letting the difficult decisions fall to the court system and local initiative. Given the potential impact of the recent decision in Barstow v. Mojave on the utility of adjudicated basins,[18] along with shortcomings in Assembly Bill 3030 (AB 3030) groundwater management plans,[19] it appears as though the state may have few remaining options to manage groundwater under existing legislation. This absence of clear legislative action defining a more formal state administrative role is seriously misguided given the importance of groundwater as a public resource and the degree to which groundwater quantity and quality have been diminished over the past 100 years.[20]

Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.

[17] Helperin, A. N., et al. (2001). California's contaminated groundwater: is the state minding the store? New York: Natural Resources Defense Council.

[18] *City of Barstow v. Mojave Water Agency* (2000). 23 Cal. 4th 1224. The California Supreme Court overturned the Appeals Court, finding that priority must be maintained when implementing a physical solution in an adjudicated basin. This will likely weaken the ability of court appointed watermasters to equitably apportion water in an overdrafted basin based on contemporary values.

[19] AB 3030 plans were an attempt of the legislature to manage groundwater. However, the plans are not binding, any party to the plan can leave at any time. There are no incentives for parties to participate, and AB 3030 plans need not overlie groundwater basins. While 156 AB 3030 plans have been adopted, none place significant restrictions on overdrafting or activities that contaminate the aquifer Department of Water Resources and C. J. Hauge (1999). Groundwater management in California: a report to the Legislature pursuant to Senate Bill 1245 (1997). Sacramento, CA: State of California..

[20] Dubrovsky, N. M., et al. (1995). Water Quality in the San Joaquin-Tulare Basins, California, 1992-95: USGS Circular 1159: U.S. Geological Survey.

Narasimhan, T. N. and N. W. T. Quinn (1996). Agriculture, Irrigation, and Drainage, on the West Side of the San Joaquin Valley, California: Unified Perspective on Hydrogeology, Geochemistry, and Management.: LBL-38498. Berkeley: Lawrence Berkeley Laboratory, University of California.

In light of significant impacts to groundwater quality and quantity in California in the form of overdraft, land subsidence, groundwater and soil salinity, nutrient and pesticide management, and industrial contamination, several important questions must be asked:

- What are the extent and nature of groundwater quality and quantity problems in the state? How do these relate to the nature of the resource infrastructure?
- How do these problems relate to existing management practices or lack thereof?
- What are the state's responsibilities concerning groundwater management? What are the current limitations to state governmental authority with regard to monitoring, quantifying existing rights and extraction, permitting future rights, and limiting existing rights?
- What have other states done to remedy groundwater overdraft and contamination? How do these approaches differ from California's?
- What statutory changes in California would promote reductions in overdraft, mitigate contamination, and help in long-term sustainable management of the groundwater resource?

California DWR states, "The State of California is not authorized by the California Water Code to manage groundwater."[21] Although the SWRCB is limited in authority to establish a broad permit system governing percolating groundwater, the California Water Code (CWC) and Constitution contain provisions that empower the SWRCB and DWR with considerable authority to conserve and protect groundwater. This thesis examines the extent and sufficiency of this authority to achieve California's broad policy goals with respect to groundwater. In particular, there is a need to examine whether existing SWRCB and DWR authority could be more fully utilized to promote the conservation and protection of groundwater or whether these existing tools are insufficient, necessitating further legislative action.

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[21] Department of Water Resources (1996). Water Facts #2: 7 Steps for Managing Groundwater Supplies. Sacramento: State of California.

The CWC § 104 reads:

> It is hereby declared that the people of the State have a paramount interest in the use of all the water of the State and that the State shall determine what water of the State, surface and underground, can be converted to public use or controlled for public protection.

In a time of worsening groundwater conditions throughout much of the state, such as in the San Joaquin Valley (SJV) and the Imperial Valley, it would appear as though the state legislature may have to utilize this authority to provide the SWRCB and DWR with additional tools to conserve and protect groundwater resources. The likelihood of such needed legislation has been recognized for several decades. In 1961-2 an Assembly Interim Committee on Water concluded:[22]

> If, in the future, there are indications of major failure in any of the local groundwater management programs, and it can be determined that local negligence or inaction was the cause, the Legislature would then have a basis to take major corrective action.

Today, as in 1978,[23] this failure continues without major corrective action on the part of the legislature. This inaction only perpetuates a cycle of uncertainty in groundwater rights and a less than optimal resource utilization. With little direction from the legislature, the courts are forced to rely on a turbulent history of case law based on decisions made long before the occurrence and flow of groundwater was fundamentally understood.

This thesis examines the approaches taken in other western states to manage groundwater and the degree of centralization in these management systems. These states have taken steps to incorporate advances in science into water law. Given the lack of local initiative in the SJV to manage groundwater, state intervention is required to promote

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[22] California Legislature. Assembly Interim Committee on Water (1962). Ground Water Problems in California : A Report of the Assembly Interim Committee on Water to the California Legislature. Sacramento, CA: Assembly of the State of California.

[23] In 1978, the Governor's Commission to Review to Review Water Rights Law documented the problems associated with groundwater California and made more than 100 pages worth of recommendations on the issue of groundwater alone. Despite these findings, the legislature enacted few of the commission's recommendations.
Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.

groundwater protection and longevity. Moreover, federal regulatory interests in groundwater via the Clean Water Act[24] and Safe Drinking Water Act[25] could provide California with incentives to develop systems of management that will avoid federal conflict in the future.[26]

B. Purpose and Scope of Research

In light of the foregoing, the main goals of this thesis are as follows:

(1) Using the western side of the SJV as an example, identify the major problem areas in groundwater management in California that require state intervention (e.g. groundwater/soil salinization, pesticide and nutrient contamination, overdraft and land subsidence, and industrial contamination);

(2) Trace the legal history of groundwater development in California to help illustrate the state's current role in administering groundwater, the nature of groundwater as a public resource, and the failures of the current management system;

(3) Examine the groundwater management approaches of Arizona, Colorado, Nebraska, New Mexico, and Texas, to provide a basis for recommending new approaches to groundwater management in California; and

(4) Develop recommendations for amending the CWC to promote reductions in overdraft and contamination.

The first part of this thesis focuses on the natural setting of groundwater in the SJV of California. This is because the resource infrastructure ultimately dictates the scope of sustainable development. The SJV was chosen as the main example because of the range of groundwater uses in the valley (agricultural, domestic, and in-stream), along with the range of problems affecting groundwater (overdraft, salinization, and pesticide/nutrient

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[24] 33 USC Sec. 1329 Nonpoint source management programs
33 USC Sec. 1313 Water quality standards and implementation plans
[25] 42 USC Sec. 300j-13. Source water quality assessment
[26] Of the states discussed in this thesis, most have been motivated to pursue groundwater management through federal coercion under the Endangered Species Act, interstate compacts, or other federal water development legislation.

contamination). Where the SJV is not a sufficient example, references are made to other regions of California.

The groundwater debate is often focused entirely on the issue of overdraft. However, attempts to remedy overdraft must also incorporate groundwater quality. Deterioration in groundwater quality impacts the quality of soils and their ability to sustain plant life. Any changes in California groundwater law should address issues of quality simultaneously with issues of quantity because water quality has equally serious implications for agricultural, domestic, and environmental uses. The purpose of this first part is to demonstrate that there are serious problems of overdrafting, salinization, and non-point source contamination in the SJV. Such problems also exist in many other regions in California. With the use of historical data and geographic information system (GIS) maps, it will be demonstrated that this problem has continued to worsen, even in light of recent efforts to improve groundwater management. Lastly, current groundwater management activities in the SJV, if they continue at current pace, will lead to a diminution of supply and quality for future generations. Additionally, degradation of groundwater quality will have a significant negative impact on plant life and the ecosystem.

The second part of this thesis examines how groundwater is currently managed in California. A review of the laws and courts cases shows how the system has evolved over time. More so than in most western states, California's groundwater management is a piecemeal system of statutory and court-made law, a mix of local and regional programming efforts, and varying degrees of groundwater control. While the variety of groundwater programs in California is large, gaps in these programs are numerous. A long chain of events must occur for a basin to come under management, particularly under AB 3030 provisions. State law also lacks coherent provisions regarding monitoring, data collection,

and analysis, a realization echoed in recent publications.[27] In the second part of this thesis, effort is made to demonstrate the relationship between these management approaches and the dilemmas present in groundwater quality and quantity.

The third part examines groundwater as a public resource in its legal context. Many opponents to increased state intervention in groundwater management postulate that strict principles of property apply to groundwater in California, and that the landowner should have the ultimate say in how the resource is used. An analysis of the relevant case law, state and federal constitutional law, and state and federal statutory law reveals that there is little ambiguity in the fact that the State of California reserves the power to regulate water by virtue of the authority granted by the California Constitution. Further, the exercise of such power does not raise constitutional takings concerns. Although limited in application to date, this authority has been upheld in the courts of California and in the courts of other states, e.g. Hawaii and Colorado. The federal role in groundwater under the Clean Water Act and United States Constitution is also briefly examined.

The fourth part examines groundwater statutes in several western states to identify the composition of groundwater management programs in a variety of institutional settings. These programs include numerous elements not found in California, such as extraction limits, pump taxes, and monitoring requirements. Most approaches to resolving the groundwater crisis in California have arisen thus far from a small set of ideas in the courts, ideas conditioned by an outdated approach to groundwater which did not consider its interconnectedness with surface water resources nor the pressure imposed by agricultural, domestic, and environmental uses in a highly populous state. Extreme burdens have been

[27] Helperin, A. N., et al. (2001). California's contaminated groundwater: is the state minding the store? New York: Natural Resources Defense Council.

placed on the groundwater resource infrastructure by overdraft and salinization for marginal economic gains. Most western states whose groundwater laws arose in settings similar to California's have recognized and acted upon the fact that legislation passed in the early 1900s was not adequate given increased pressures on the resource. Arizona, Colorado, Nebraska, New Mexico, and Texas, have all drastically revised their groundwater laws since 1950. Although each approach is different, they all have similar structures, which include elements of state oversight, information collection, and goal setting. California has not followed their leadership, despite the availability of scientific and legal institutions within the state and pressures for increased monitoring and management under Clean Water Act obligations.

The fifth part of this thesis makes recommendations for improving state administration of groundwater in California. It also discusses other approaches to groundwater protection (groundwater transfers and banking) and barriers to implementation of groundwater reform legislation. In conclusion, an attempt is made to ascertain whether California should expand the role of state agencies in administering and managing groundwater.

C. Literature Review

The majority of referenced scientific, legal, and government works are presented throughout this thesis as appropriate. However, a few bodies of knowledge that are essential to comprehend California's water context are summarized below.

1. Centralized Decision-making in Groundwater

Our main interest in pursuing the role of the state government in resolving California's groundwater dilemmas stemmed from a 1984 paper titled Centralized Decision-making in the Administration of Groundwater Rights: The Experience of Arizona,

California, and New Mexico and Suggestions for the Future[28] and from a 1996 article titled "Whiskey is for Drinkin' but Water is for Fightin' About'": A First-hand Account of Nebraska's Integrated Management of Ground and Surface Water Debate and the Passage of LB108.[29] The former article plainly describes the history of groundwater rights and law in the western United States from its common law roots to recent legislation. It also explains a period of change in groundwater law that, in our opinion, has coincided with a growing scientific understanding of the physical, chemical, and biological attributes of groundwater. While the article described significant changes in Arizona and New Mexico in developing an effective system of groundwater management, it was less optimistic about the future of California groundwater. The author cited several defeated legislative measures to increase state control in groundwater as a way of remedying overdraft and extensive litigation. Given the somewhat outdated nature of the paper and its relevance to only groundwater quantity management, a contemporary and exhaustive view of the subject might be revealing.

The latter article discusses the events leading to the passage in 1992 of Legislative Bill 108 (L.B. 108) in the Nebraska Legislature, a bill that amended the state's Groundwater Management Act. The Act is progressive in nature, taking into account the interconnections between surface water and groundwater that have long been overlooked in much of western water law. This law, sharing similarities with the laws of Arizona, Colorado, New Mexico, and Texas, has increased the authority of local natural resource districts to manage groundwater and surface water together. These actions arguably constitute a more effective approach for promoting long-term quality and quantity protection of groundwater resources

[28] Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688.
[29] Mossman, S. D. (1996). ""Whiskey is for Drinkin' but Water is for Fightin' About': A First-hand Account of Nebraska's Integrated Management of Ground and Surface Water Debate and the Passage of L.B. 108"." Creighton Law Review 30 Creighton L. Rev. 67.

than those presently found in California. It is notable that these approaches have moved away from traditional political boundaries towards physiographic boundaries and groundwater basins as units of water management.[30] To date there has been no comparison of these governmentally created natural resource districts to decentralized systems in California. Such a comparison might be revealing about the positive traits of each.

2. Groundwater as a Public Resource Controlled by the State

Several previous writings have contemplated the role of groundwater as a public resource.[31] Groundwater in the natural environment experiences many of the problems associated with common property resources that go unmanaged.[32] Early court cases that follow Acton v. Blundell[33] failed to recognize that groundwater is a common resource, helping foster non-management of the resource. Although California has since 1903 not recognized the English Rule with respect to groundwater, it is still not managed as a

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[30] This approach is similar to that championed by J.W. Powell a century ago in Powell, J. W. and U.S. Geographical and Geological Survey of the Rocky Mountain Region (1879). Report on the lands of the arid region of the United States : with a more detailed account of the lands of Utah. Washington, D.C.: U.S. Government Printing Office.

[31] University of Colorado Boulder (1987). Water as a Public Resource : Emerging Rights and Obligations. Eighth annual summer program, Boulder, Colo., Natural Resources Law Center,.
Koehler, C. L. (1995). "Water Rights and the Public Trust Doctrine: Resolution of the Mono Lake Controversy." Ecology Law Quarterly 22 Ecology L.Q. 541.
Bokum, C. (1996). "Implementing the Public Welfare Requirement in New Mexico's Water Code." Natural Resources Journal, Fall 1996.
California Trout (1996). Putah Creek Public Trust Victory: CalTrout's Mono, Bear Creek Precedents Applied. Internet: California Trout, 1999, http://www.caltrout.org/logs/79/toc79.htm.
Dumars, C. T. (1996). "Changing Interpretations of New Mexico's Constitutional Provisions Allocation Water Resources: Integrated Private Property Rights and Public Values." New Mexico Law Review 26 N.M.L. Rev. 367.
Paul, J. T. (1996). The Public Trust Doctrine: Who Has the Burden of Proof? Western Association of Wildlife and Fisheries Administrators, Honolulu, Hawaii, Department of Land and Natural Resources.
Center for Private Conservation (1999). Conservation and the Public Trust Doctrine: Center for Private Conservation.
Swenson, E. (1999). "Public Trust Doctrine and Groundwater Rights." University of Miami Law Review 53 U. Miami L. Rev. 363.

[32] Ostrom, E., et al. (1994). Rules, Games and Common-Pool Resources. Ann Arbor: University of Michigan Press.

[33] Acton v. Blundell extablished the English rule of capture, wherein the property owner is entitled to all of the water he can "capture" via wells on his own property.
Acton v. Blundell (1843). 12 Mees. & W. 324, 354, 152 Eng. Rep. 1223, 1235 (Ex. Ch. 1843).

common resource both in the physical sense (i.e. connection with surface water) and in the legal sense (i.e. the public should have some say over when and how the resource is utilized).

There is a significant legal history in California holding groundwater as a public resource. This includes California constitutional provisions justifying state involvement in the management of groundwater. The importance of groundwater extends beyond the boundaries of the overlying landowner. It extends to surrounding hydrological and ecological conditions. This thesis examines the role of state government in protecting this public resource, particularly with regard to management of the resource when responsibilities are partitioned among federal, state, and local governmental units.

3. Groundwater Resources of the San Joaquin Valley

In order to justify our proposal for increased state involvement in groundwater management, the challenges of managing groundwater quality and quantity in California are documented and discussed. Ever since the English case of Acton v. Blundell in 1843 made a distinction between surface water and groundwater, science and law have been slow to make connections among surface water, groundwater, and the land.[34] This barrier has spawned a long series of laws and regulations that address groundwater, surface water, and land separately.[35] The example of the SJV as an interconnected system will provide evidence of the need to seek solutions that bridge the programmatic and legal gaps among surface water,

[34] Grover, G. G. and J. John F. Mann (1991). "Acton v. Blundell Revisited: "Property" in California Groundwater." Western State University Law Review 18 W. St. U.L. Rev. 589.
[35] University of California Water Resources Center, et al. (1996). Making the connections. Twentieth Biennial Conference on Ground Water, San Diego, California, Centers for Water and Wildland Resources University of California.

groundwater, and the land.[36] Efforts to revise groundwater policy in California should include present knowledge about these interconnections.[37]

D. Research Method

The analytic framework proposed and utilized by William Blomquist in several articles about groundwater management in the federal system is employed in this thesis.[38] These previous works have focused largely around the institutional barriers to resource optimization, i.e. what institutional changes are necessary to foster optimal use without degradation in quality and quantity? The works of Blomquist are some of the most

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[36] Dolcini, A. J. (1966). A critical appraisal of the integrated management of California's ground and surface water resources. Sacramento: State of California.
Malone, L. A. (1990). "The Necessary Interrelationship Between Land Use and Preservation of Groundwater Resources." UCLA Journal of Environmental Law & Policy 9 UCLA J. Envtl. L. & Pol'y 1.
National Research Council and Committee on Long-Range Soil and Water Conservation (1993). Soil and water quality : an agenda for agriculture. Washington, D.C.: National Academy Press.
Hosper, S. H. (1995). Integrated water resources management. New York: Pergamon.
Ward, R. C. (1995). "Integrated watershed management : a new paradigm for water management?" Water resources update: 2-74.
Narasimhan, T. N. and N. W. T. Quinn (1996). Agriculture, Irrigation, and Drainage, on the West Side of the San Joaquin Valley, California: Unified Perspective on Hydrogeology, Geochemistry, and Management.: LBL-38498. Berkeley: Lawrence Berkeley Laboratory, University of California.
Natural Resources Conservation Service (1997). Water Quality and Agriculture: Status, Conditions, and Trends: Working Paper #16. Washington, D.C.: U.S. Department of Agriculture.
Thomas, R. J., et al. (1999). Integrated natural resource management : the approach of the soil, water and nutrient management program. Cali, Colombia: Ciat.
Winter, T. C., et al. (1999). Ground Water and Surface Water: A Single Resource: Circular 1139. Denver, CO: U.S. Geological Survey.
Tarlock, A. D. (2000). "Putting Rivers Back in the Landscape: The Revival of Watershed Management in the United States." Hastings West-Northwest Journal of Environmental Law and Policy 6 Hastings W.-N.W. J. Env. L. & Pol'y 167.
[37] *United States of America v. State Water Resources Control Board* (1986). 182 Cal.App.3d 82.
[38] Blomquist, W. and U.S. Geological Survey (1988). The performance of institutions for groundwater management. Bloomington, Indiana: Workshop in Political Theory & Policy Analysis Indiana University.
Blomquist, W. (1991). "Exploring State Differences in Groundwater Policy Adoptions, 1980-1989." Publius 21(Spring 1991): 101-115.
Blomquist, W. A. (1991). "Taking federalism underground : managing water resources." Intergovernmental perspective 17(3): 6-7, 24.
Blomquist, W. A. (1991). Coordinating water resources in the federal system: the groundwater-surface water connection. Washington, D.C.: U.S. Advisory Commission on Intergovernmental Relations.
Blomquist, W. A. (1992). Dividing the waters : governing groundwater in Southern California. San Francisco: ICS Press.
Blomquist, W. A. (1999). "Archives, institutions, and water in California." WRCA news 6(1): [1], 3.

comprehensive efforts that link an understanding of the physical groundwater setting to the legal institutions that manage it.

Specifically this thesis builds upon the Institutional Analysis and Development (IAD) framework.[39] This framework is composed of stakeholders and the situation in which they interact. It is a useful tool for identifying obstacles to optimal resource use, obstacles often present with common property resources such as groundwater. Within the IAD framework, obstacles to optimality are perceived as taking the form of heterogeneities in (1) the physical world, (2) the community, and (3) rules-in-use. For example, the presence of a heterogeneity in the physical system, such as the amount of groundwater available under one's land versus that under another one's land, will create a difference in how a policy to mitigate overdraft might affect adjacent landowners. Therefore, heterogeneity in the action arena can often be considered as a barrier to optimality.

First, attributes of the physical world that are of interest in this thesis are those which affect the quality or quantity of groundwater and, to a lesser extent, resources that are complements to groundwater, such as soil quality. Generally, these attributes can be viewed as public goods or common pool resources, or also as mobile or stationary resources.[40] These attributes are discussed in detail with regard to the SJV and California in this thesis through the comprehensive resource frameworks presented by several authors.[41]

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[39] Schlager, E. and W. Blomquist (1998). Resolving Common Pool Resource Dilemmas and Heterogeneities Among Resource Users. Crossing Boundaries, The Seventh Annual Conference of the International Association for the Study of Common Property, Vancouver, British Columbia.
[40] Schlager, E., et al. (1994). "Mobile Flows, Storage, and Self Organizing Insitutions for Common Pool Resources." Land Economics 70(3): 294-317.
[41] Toth, J. (1995). "Hydraulic Continuity in Large Sedimentary Basins." Hydrogeology Journal 3(4): 4-16.
Narasimhan, T. N. and N. W. T. Quinn (1996). Agriculture, Irrigation, and Drainage, on the West Side of the San Joaquin Valley, California: Unified Perspective on Hydrogeology, Geochemistry, and Management.: LBL-38498. Berkeley: Lawrence Berkeley Laboratory, University of California.
Toth, J. (1999). "Groundwater as a geologic agent: An overview of the causes, processes, and manifestations." Hydrogeology Journal 1999(7): 1-14.

Second, attributes of the community are the "generally accepted norms of behavior, the level of common understanding about action arenas, the extent to which the preferences are homogenous, and the distribution of resources among members."[42] The community, in the form of traditional patterns of water allocation and use in California, along with reluctance on the part of the legislature to act, are examples of the importance of community in effecting resource optimization. These and other attributes of California customs and history that affect the patterns of heterogeneity that are visible among stakeholders are examined in this thesis.

Third, rules-in-use are defined as "prescriptions that define what actions (or outcomes) are required, prohibited, or permitted, and the sanctions authorized if the rules are not followed[43]." Specifically there are six categories of such rules:

(1) Boundary— rules that determine what criteria individuals must meet in order to participate in the situation.
(2) Position— rules that determine what place stakeholders occupy in the situation.
(3) Authority and scope— rules that define the actions that participants shall, shall not, or may make.
(4) Aggregation— rules that translate actions into outcomes.
(5) Information— rules that determine the information available to each stakeholder.
(6) Payoff— rules that determine what benefits or costs are associated with each action and how these costs and benefits will be distributed.

To add credence to our examination of such rules-in-use in California, case studies of Arizona, Colorado, Nebraska, New Mexico, and Texas are included in this thesis. These

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Winter, T. C., et al. (1999). Ground Water and Surface Water: A Single Resource: Circular 1139. Denver, CO: U.S. Geological Survey.
Winter, T. C. (2001). "The Concept of Hydrologic Landscapes." Journal of the American Water Resources Association 37(2).
[42] Ostrom, E., et al. (1994). Rules, Games and Common-Pool Resources. Ann Arbor: University of Michigan Press.
[43] Ostrom, E., et al. (1994). Rules, Games and Common-Pool Resources. Ann Arbor: University of Michigan Press.

case studies provide the basis from which recommendations for improving the rules-in-use in California could be modified to promote optimality.

Lastly, differences in the stakeholders themselves can also represent a heterogeneity distinguishable from the setting. Priorities in water rights are a good example of such actor-related heterogeneities.

Chapter II. The Groundwater System in the San Joaquin Valley, California

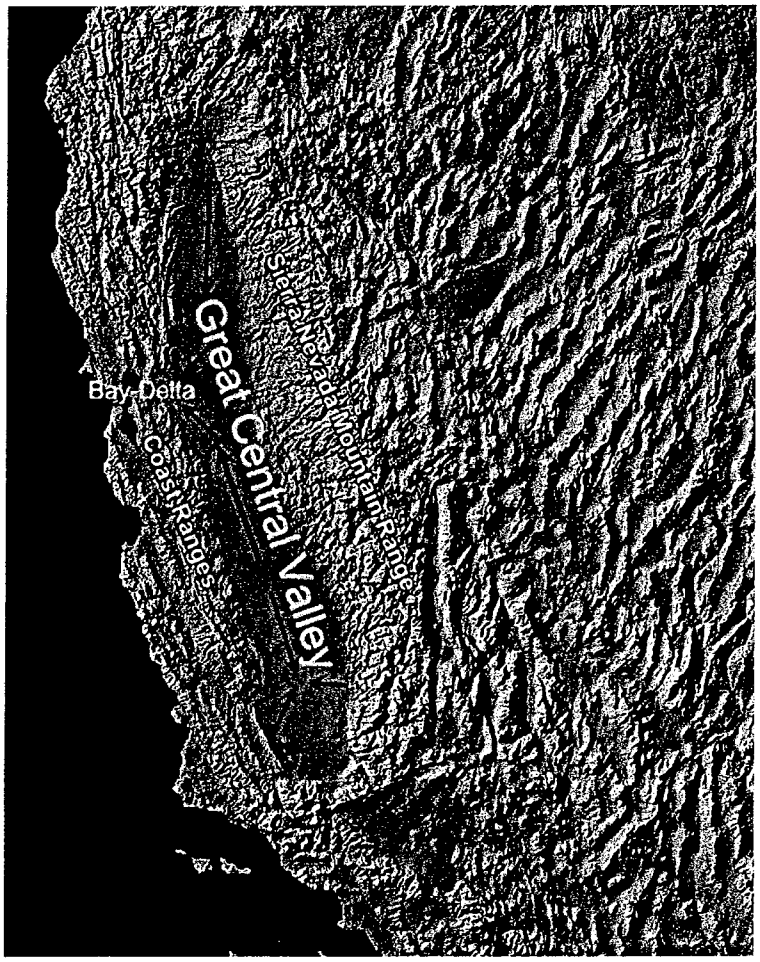

Figure 1: Shaded Relief Map of California's Great Central Valley

The goal of this section is to elucidate the geological, physical, and chemical attributes of groundwater in the SJV as a basis for comprehending:

(1) how groundwater and surface water flows are interconnected in the valley at large scales,

(2) how groundwater extraction and land use impact groundwater chemistry and quality,

(3) how agricultural impacts to water quality and quantity are governed by the natural setting, and

(4) how knowledge of the flow patterns of groundwater may improve the management of agriculture so that the resource infrastructure can sustain agriculture over long periods of time.

In the SJV, an interconnected system of groundwater, surface water, and land is out of balance due to prolonged, aggressive human intervention. The unique hydrological problems found in this region help to make a strong argument for a more flexible, standardized, state-administered system of groundwater management in California. The valley further helps illustrate the weaknesses found in current management tools such as adjudicated basins, AB 3030 plans, and other techniques. These weaknesses are particularly apparent in large basins where the impacts are displaced through space and time. Lastly, it helps to demonstrate the need for an integrated framework of data collection, coordination, and analysis that is necessary to devise strategies for preserving the integrity of groundwater resources for future generations.

A. Natural Setting

1. Physiography and Geology

When viewed from space, the physiography of California is dominated by the Great Central Valley that extends from the far northern reaches of California near Redding and the Trinity Range down all the way to the Tehachapi Mountains in the south (see Figure 1). This Great Central Valley is bounded on the east by the Sierra Nevada Range (elevation 2,000-4,000 meters (6,000 to 13,000 feet)) and on the west by the Coast Ranges (elevation 1,000-2,000 meters (3,000 to 6,000 feet)). The southern portion of the Great Central Valley, extending from the delta to the Tehachapi Mountains, is the SJV.

Forming the eastern boundary of the SJV, the Sierra Nevada range spans approximately 640 kilometers from the Tehachapi Mountains in the south to the Cascade Range in the north. The Sierra Nevada range in height from 100 meters (300 feet) at the SJV floor to over 4,000 meters (13,000 feet) and mark the western terminus of the basin and range province.[44] The elevation of the Sierra Nevada, combined with high rates of precipitation, provide a powerful driving force for much of the groundwater and surface water systems of the SJV. See Figure 2 for a depiction of the groundwater basins in the SJV and surrounding areas.[45]

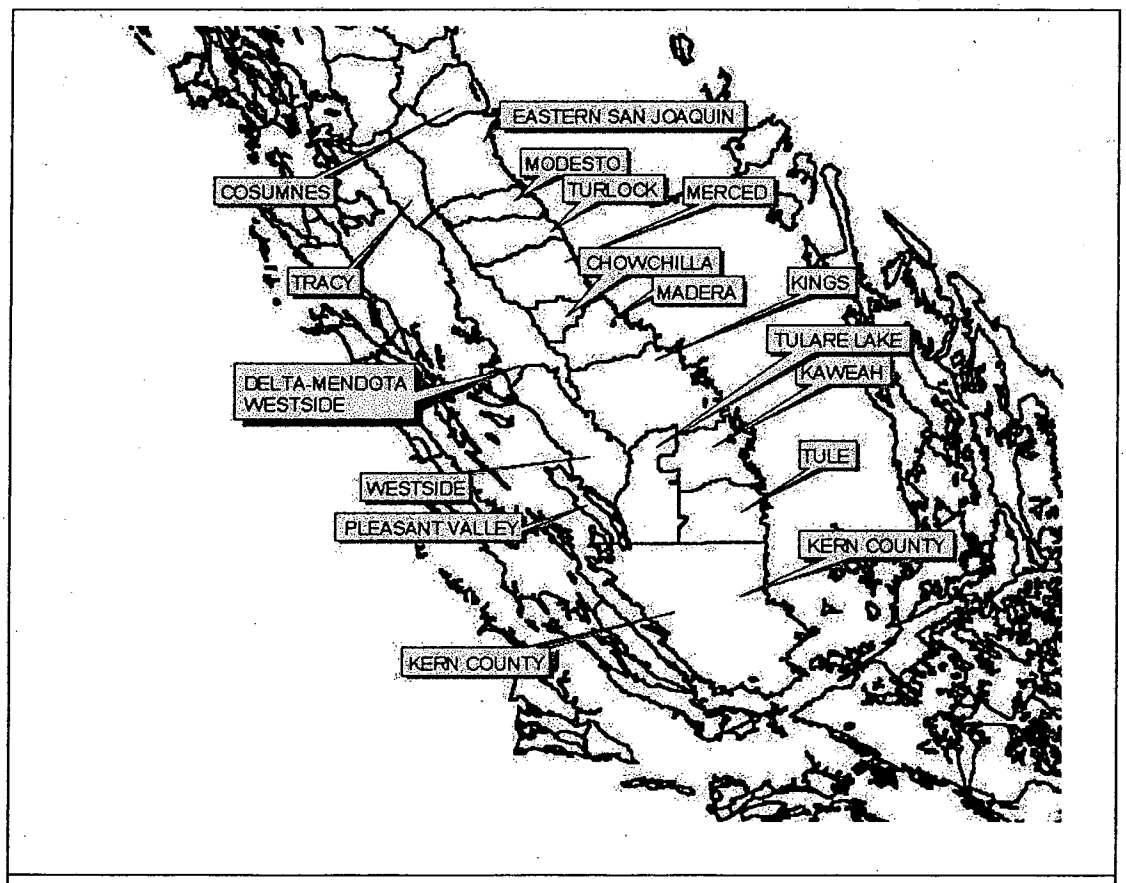

Figure 2: Groundwater Basins of the San Joaquin Valley as Defined by DWR Report 118

[44] Norris, R. M. and R. W. Webb (1990). Geology of California. New York: John Wiley & Sons, Inc.
[45] Adapted from Department of Water Resources (1980). Bulletin 118-80: Ground Water Basins in California: 118-80: State of California.

A long fault along the eastern side of the mountains denotes the forces that have pushed the Sierra Nevada complex up approximately 4,500 meters (14,000 feet), a process which began approximately 200 million years before present. The resulting western tilt of the range towards the valley is more gradual. The higher elevations of the Sierra Nevada have also faced extensive glaciation since the beginning of the Pleistocene epoch, which began 2 million years before present. Many of the present-day watercourses attribute their configuration to glaciation. The most recent glacial stage ended approximately 10,000 years before present.[46]

The Coast Ranges extend north for about 800 kilometers from Santa Barbara in the south to near the Oregon border in the north. This range is bisected by the outlets of the San Joaquin and Sacramento Rivers at San Francisco Bay. Although lower in elevation than the Sierra Nevada, the Coast Ranges are quite craggy given their more recent formation and reduced weathering time. Tectonic forces have gradually raised the Coast Ranges over geologic time. Estimates place the peak rise of the Coast Ranges at about 5 million years before present.

Drainage in the Coast Ranges is dominated by patterns of rainfall, particularly high in the northern portions of the range. The Eel, Klamath, Mad, and Russian rivers are the major watercourses north of the bay-delta region. In the southern Coast Ranges, precipitation is less and the majority of it falls on the western slope, supplying the Salinas, Cuyama, and Santa Ynez rivers. Rivers on the east side of the southern Coast Ranges are largely ephemeral, such as Los Banos and Panoche Creeks.

Until approximately three million years before present, the Great Central Valley was part of the Pacific Ocean, a shallow shelf of the continental plate. The tectonic activity of

[46] Norris, R. M. and R. W. Webb (1990). Geology of California. New York: John Wiley & Sons, Inc.

the oceanic and continental plates along the San Andreas fault system gave rise to the Coast Ranges, that soon sealed off the valley. The valley floor, once a marine depositional environment, soon gave way to a brackish water and, later, a fresh water system from the inflow of precipitation and runoff. Marine sediments can exceed 6,500 meters (21,000 feet) in thickness near Bakersfield, while non-marine (lacustrine and alluvial) sediments exceed 1,000 meters (3,000 feet) throughout much of the valley.

The SJV is a large and elongated intermontane sedimentary basin filled with a thick sequence of sediments. The upper part of the sedimentary sequence extends from the land surface to about 1,600 meters (5,000 feet) and constitutes a groundwater system with considerable reserves of fresh water. Throughout much of this valley trough, the Pleistocene Corcoran Clay layer of the Tulare Formation divides the groundwater flow system into an upper semiconfined zone and a lower confined zone.[47] This Corcoran Clay consists of clayey silts and silty clays and hence acts to significantly retard the flow of water.[48] It covers approximately 13,000 square kilometers (5,000 square miles). Below the Corcoran Clay layer, the lower confined zone consists of poorly consolidated flood-plain, deltaic, alluvial-fan, and lacustrine deposits of the Tulare Formation. The sand beds in the confined zone constitute highly productive aquifers.

Within the semi-confined zone, above the Corcoran Clay layer, three hydrogeologic units can be identified: Coast Range alluvium (marine) on the western side of the valley, Sierran sand (micaceous) on the eastern side, and flood-basin deposits which occur on the surface along the valley axis. The Corcoran Clay was formed from lake deposits of clayey silt

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[47] Page, R. W. and U.S. Geological Survey (1983). Geology of the Tulare Formation and other continental deposits, Kettleman City area, San Joaquin Valley, California : with a section on ground-water management considerations and use of texture maps. Sacramento, CA: U.S. Geological Survey.
[48] Belitz, K., et al. (1990). Character and evolution of the ground-water flow system in the central part of the western San Joaquin Valley, California. Washington, D.C.: U.S. Geological Survey.

and creates a low permeability horizon varying in thickness from 7 to 40 meters (20 to 120 feet). It occurs approximately at depths of 130 meters (400 feet) in the valley trough and at greater depths along the valley flanks.[49]

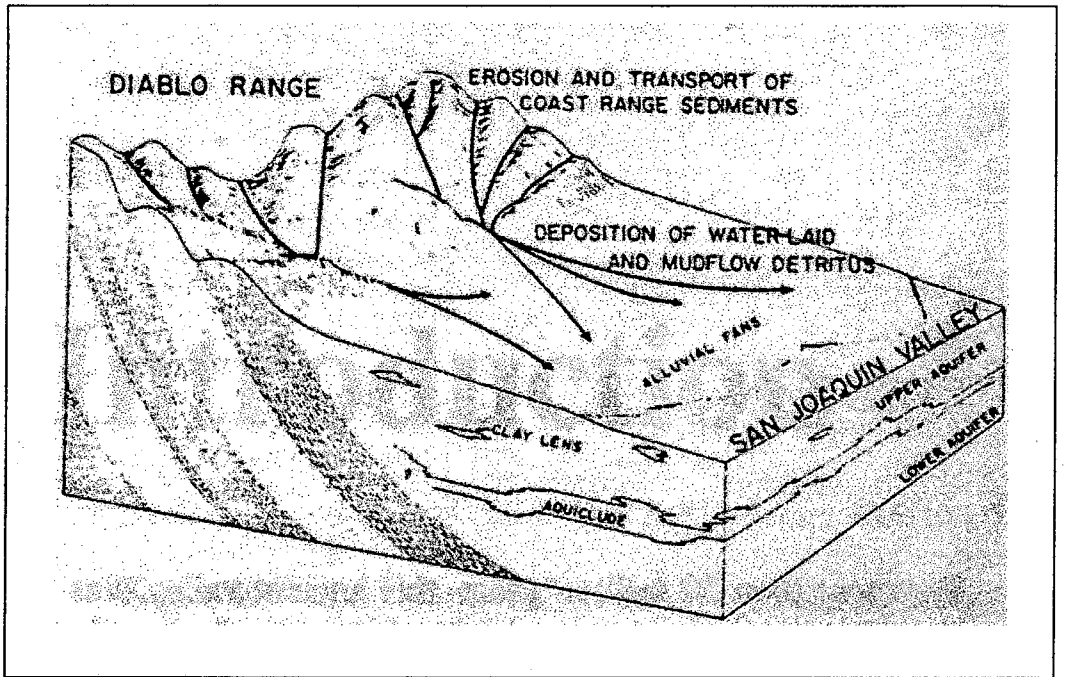

Figure 3: Diagram of Alluvial Fans Along the Western Border of the San Joaquin Valley[50]

The Coast Range alluvium on the west side is generally oxidized and ranges in thickness from 300 meters (900 feet) along the Coast Ranges to zero meters closer to the valley's axis.[51] The alluvium has accumulated from dozens of ephemeral streams, creating fans that range in size from one to more than 650 square kilometers (250 square miles).[52] The largest two fans were formed by Los Gatos and Panoche Creeks. These deposits range greatly in texture and permeability based on position along the alluvial fan (see Figure 3).

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[49] Belitz, K., et al. (1990). Character and evolution of the ground-water flow system in the central part of the western San Joaquin Valley, California. Washington, D.C.: U.S. Geological Survey.
Belitz, K., et al. (1993). Numerical simulation of ground-water flow in the central part of the western San Joaquin Valley, California. Washington, D.C.: U.S. Geological Survey.
[50] Adapted from Letey, J., et al. (1986). An Agricultural Dilemma: Drainage Water and Toxics Disposal in the San Joaquin Valley: 3319. Oakland: University of California.
[51] Page, R. W. (1986). Geology of the fresh ground-water basin of the Central Valley, California : with texture maps and sections. Washington, D.C.: U.S. Geological Survey.
[52] Bull, W. B. and Department of Water Resources (1964). Geomorphology of segmented alluvial fans in western Fresno County, California. Washington D.C.: U.S. Geological Survey.

The apex of the alluvial fan or fanhead is characterized by significantly coarser deposits than lower portions. Composition is typically 80 to 100 percent sand and less than 20 percent sandy clay.[53] The distal-fan deposits are 20 percent sand plus gravel and are coarse textured near stream channels.

On the east side, alluvium of Sierran origin is typically micaceous sand, 130 to 160 meters (400 to 500 feet) thick along the valley's axis. To the west and east of the valley trough the thickness of these sediments decreases. The Sierran sand is reduced in the valley trough and is highly permeable.[54] Flood basin deposits have created a thin sheet over the Sierran sand in the valley trough and range in thickness from 1.5 to 7 meters (5 to 35 feet). Texture varies greatly but is generally fine-textured, moderately to densely compacted clays, providing a low permeability barrier to the system.[55]

Erosional process have created an interlaced system in the valley of Sierran sand and Coast Range alluvium. Given the varied textual and geochemical properties of each, the situation is complex to understand and manage.

2. Climate

The climate of the SJV is Mediterranean and Steppe, characterized by hot, dry summers and mild, wet winters, thus allowing for a year-round growing season (see Figure 4). About 85 percent of the precipitation falls during the winter from November to April. Most of the precipitation that falls on the valley floor evaporates before it can infiltrate downward to become recharge. Given that much of the moisture that moves eastward from

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[53] Laudon, J., et al. (1989). Texture and depositional history of near-surface alluvial deposits in the central part of the western San Joaquin Valley, California. Sacramento: U.S. Geological Survey.
[54] Davis, G. H., et al. (1959). Ground-water Conditions and Storage Capacity in the San Joaquin Valley, California: Water Supply Paper 1469. Washington, D.C.: U.S. Geological Survey.
[55] Belitz, K., et al. (1990). Character and evolution of the ground-water flow system in the central part of the western San Joaquin Valley, California. Washington, D.C.: U.S. Geological Survey.

the Pacific Ocean is intercepted by the Coast Ranges, the valley is in a rain shadow. Annual precipitation decreases from east to west and from north to south, with an average of about 43 centimeters (17 inches) in the northern part of the SJV, to about 15 centimeters (6 inches) in the southern part of the SJV. Rainfall quantities fluctuate greatly from year to year. In the prevalent arid climate, annual precipitation is exceeded by potential evapotranspiration throughout the entire valley, leading to an annual moisture deficit.[56]

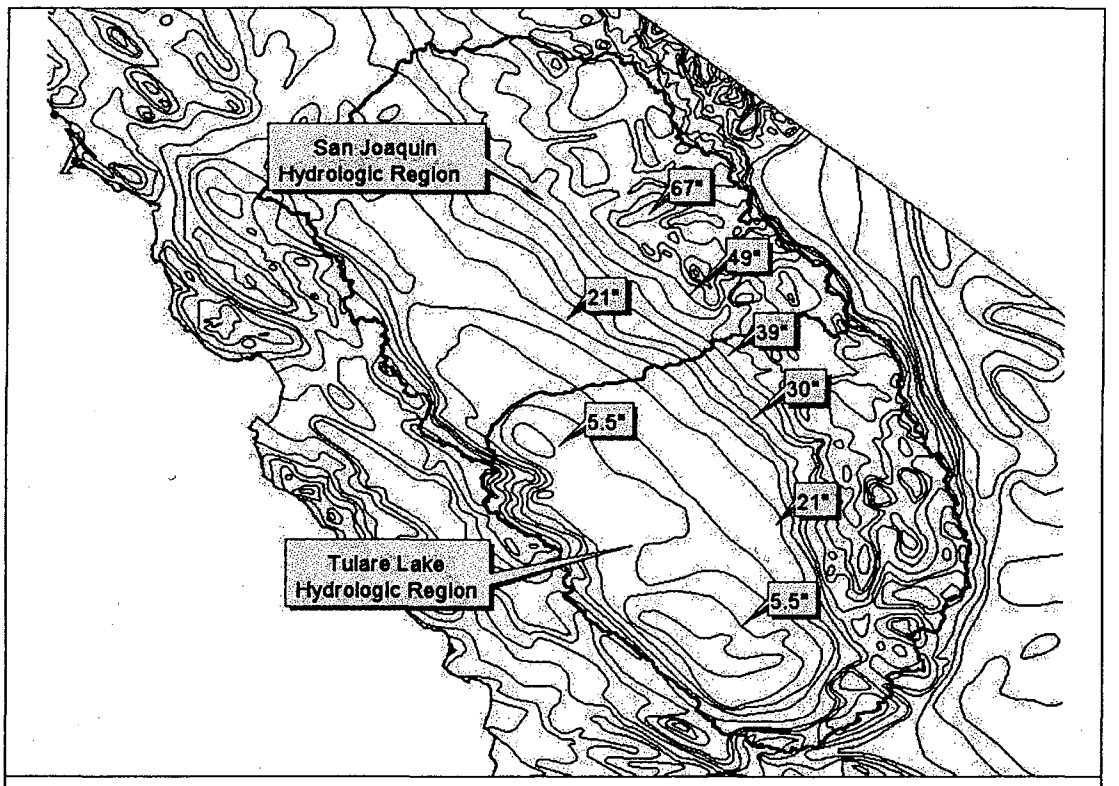

Figure 4: Average Annual Precipitation in the San Joaquin Valley (inches)

In contrast, the mountains surrounding the SJV capture precipitation from eastward moving weather systems and have an annual surplus of moisture. Annually, precipitation can exceed 200 centimeters (80 inches) in the Sierra Nevada. Annual runoff from rainfall

[56] Planert, M. and J. S. Williams (1995). California, Nevada: U.S. Geological Survey, Ground Water Atlas of the United States, segment 1, Hydrologic Investigations Atlas: HA-730-B. Reston: USGS.

and snowmelt is approximately 13.8 cubic kilometers (11.2 million acre-feet (MAF));[57] most of the runoff originates in the Sierra Nevada. This water flows to the valley in perennial streams and provides nearly all the average annual 30 centimeters (12 inches) of recharge the valley aquifer system receives. Runoff from the Coast Ranges is principally on the western slopes to the Pacific Ocean.[58]

3. Rivers and Streams

The northern portion or Sacramento Valley is drained by the Sacramento River and its several tributaries. The southern portion, the SJV, is comprised of an enclosed basin at the extreme south with no natural outlets, the Tulare Lake Hydrologic Region (TLHR), and of the San Joaquin Hydrologic Region (SJHR) which is drained by the San Joaquin River. At the confluence of the Sacramento and San Joaquin Rivers is a lowland complex of inland marshes, brackish water systems, and a delta which extends to San Francisco Bay and out underneath the Golden Gate Bridge to the Pacific Ocean. The delta has an area of approximately 2,990 square kilometers (1,150 square miles or 738,000 acres). It receives drainage from approximately 158,000 square kilometers (61,000 square miles) or 37 percent of the state. Delta inflow ranges widely from 7.4 to 85 cubic kilometers (6 to 69 MAF) per year with an average of 30 cubic kilometers (24 MAF). The TLHR and the SJHR together constitute the SJV.

There are four major rivers in the SJHR (San Joaquin, Merced, Tuolumne, and Stanislaus) and four in the enclosed TLHR to the south (Kern, Kaweah, Kings, and Tule). The San Joaquin River drains northwards to the delta (see Figure 5). Streams of the

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[57] Department of Water Resources (1998). Bulletin 160-98: California Water Plan Update. Sacramento: State of California.
[58] Department of Water Resources (2000). California Data Exchange Center. Internet: State of California, , http://www.cdec.ca.gov.

enclosed TLHR drain into Buena Vista Lake and other lowlands. Before the 1930s, these streams drained into Tulare Lake, which has since vanished due to the massive reclamation of land for agriculture.

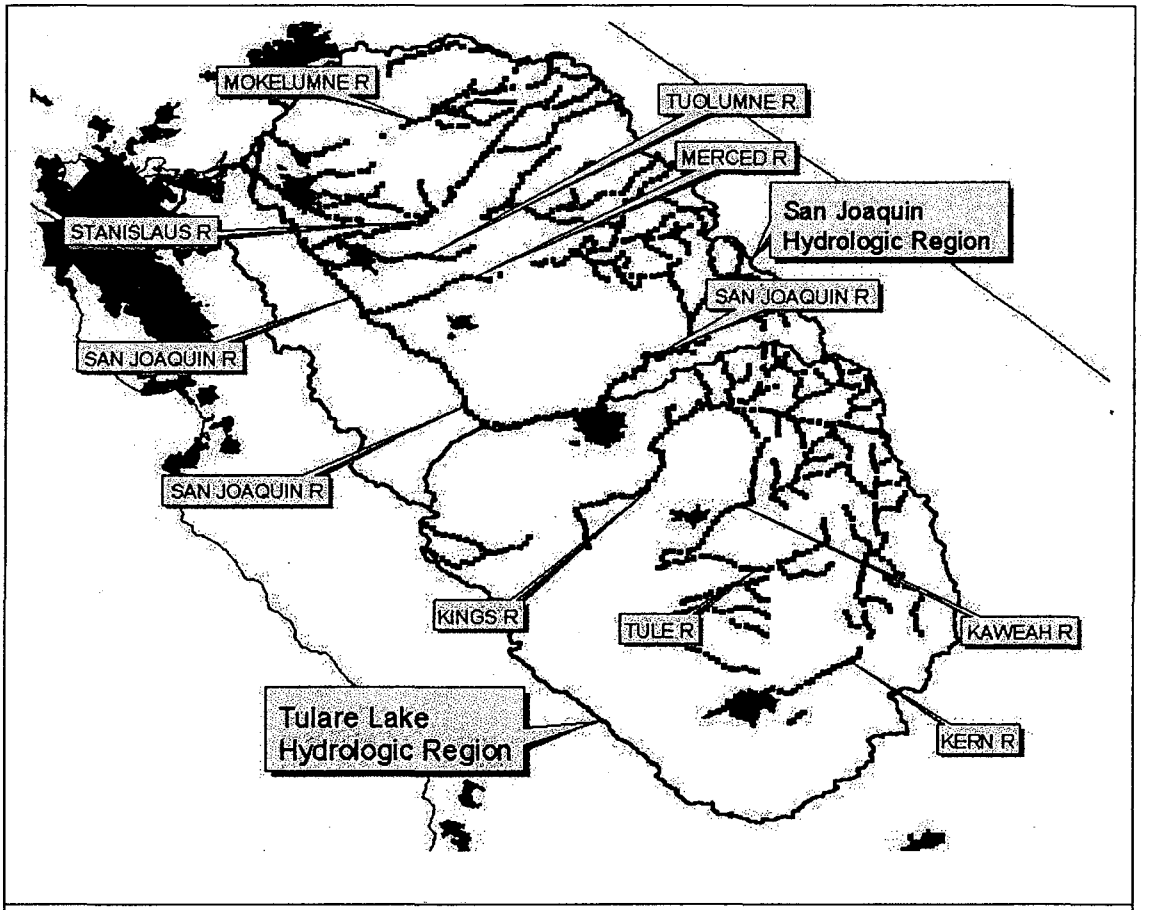

Figure 5: Major Rivers and Basins of the San Joaquin Valley

4. The Groundwater Flow System

The flow and chemistry of groundwater in the SJV is dictated by the climate, geomorphology, geology, and biotic activities of the region. Human intervention has had a large influence on this system over the last 100 years, greatly altering patterns and volumes of recharge, discharge, flow, and chemistry. Two distinct periods of human action can be defined: (1) before the advent of high capacity, submersible pumps (~1920s) and (2) during

high exploitation (1930-1960), before the major Central Valley Project (CVP) and State Water Project (SWP) deliveries augmented extraction.

Recharge in the groundwater budget of the SJV is comprised of the following: precipitation; irrigation return flows; and creeks, streams, unlined canals, and ephemeral lakes. Discharge is composed of losses to sloughs and streams, drains, and pumping wells. Changes in storage in the semi-confined zone, confining units, confined zone along with movement between these units also affect the budget. Estimates place the usable capacity of the SJV at 99 cubic kilometers (80 MAF).[59]

In order to appreciate the groundwater resources of the SJV and its ability to sustain beneficial uses for present and future generations, it is essential to comprehend the main attributes of the groundwater flow system. All the groundwater in the SJV is derived from rainwater. Water in the near-surface soil and shallow aquifers may be a few months to a few years old while water in the aquifers of the confined zone may have fallen as precipitation several thousand years ago. Thus, the key to understanding the water infrastructure of the SJV lies in knowing the fate of the rainwater, once it falls on the land surface. This fate of rainwater is dictated by two fundamental facts, namely, (1) groundwater is driven by gravity, and (2) groundwater interacts chemically with the soils and sediments. The profound consequences of these two fundamental facts are briefly outlined below.

Ultimately, the entire flow system is driven by gravity. Rainwater infiltrating below the land surface on the higher elevations and slopes of the Coast Ranges and the Sierra Nevada possesses high potential energy, just as water stored in storage tanks at high elevation. Thus, these higher elevations constitute areas of "recharge." Groundwater moves

[59] Department of Water Resources (1975). Bulletin 118: California's ground water. Sacramento: State of California.

down towards the lower parts of the basin from these recharge areas. Within the sediments, the groundwater flow paths are dictated by the ability of the sediments to transmit water. Sands offer low resistance to water while silts and clays offer much higher resistance. A consequence is that gravity-driven forces push groundwater upwards towards the land surface all along the lower parts of the valley as shown schematically in Figure 6.

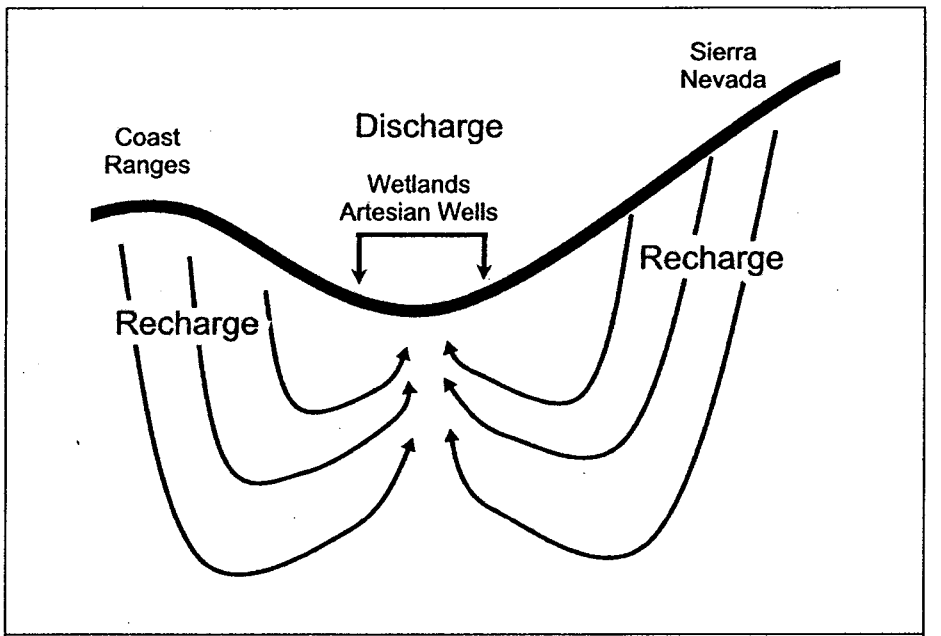

Figure 6: Conceptualized, Gravity-driven Flow Paths in the San Joaquin Valley

In this simple figure, the arrows show the direction of movement of groundwater from areas of recharge to areas of discharge. Prior to 1850, a vast tract of wetlands and deep artesian wells existed from south of Bakersfield (in the TLHR) to north of Stockton (in the SJHR).[60] These wetlands and artesian wells were merely indicative of the fact that the axis of the valley is a large discharge area for shallow groundwater (above the Corcoran Clay) as well as for deep groundwater (in the confined system below the Corcoran Clay).

[60] Hall, W. H. and California. Office of State Engineer (1886). Physical data and statistics of California. Tables and memoranda relating to rainfall, temperature, winds, evaporation, and other atmospheric phenomena; drainage areas and basins, flows of streams, descriptions and flows of artesian wells, and other factors of water supply; mountain, valley, desert, and swamp-land areas, topography of stream channels, elevations above the sea, and other topographical features. Sacramento, CA: State of California.

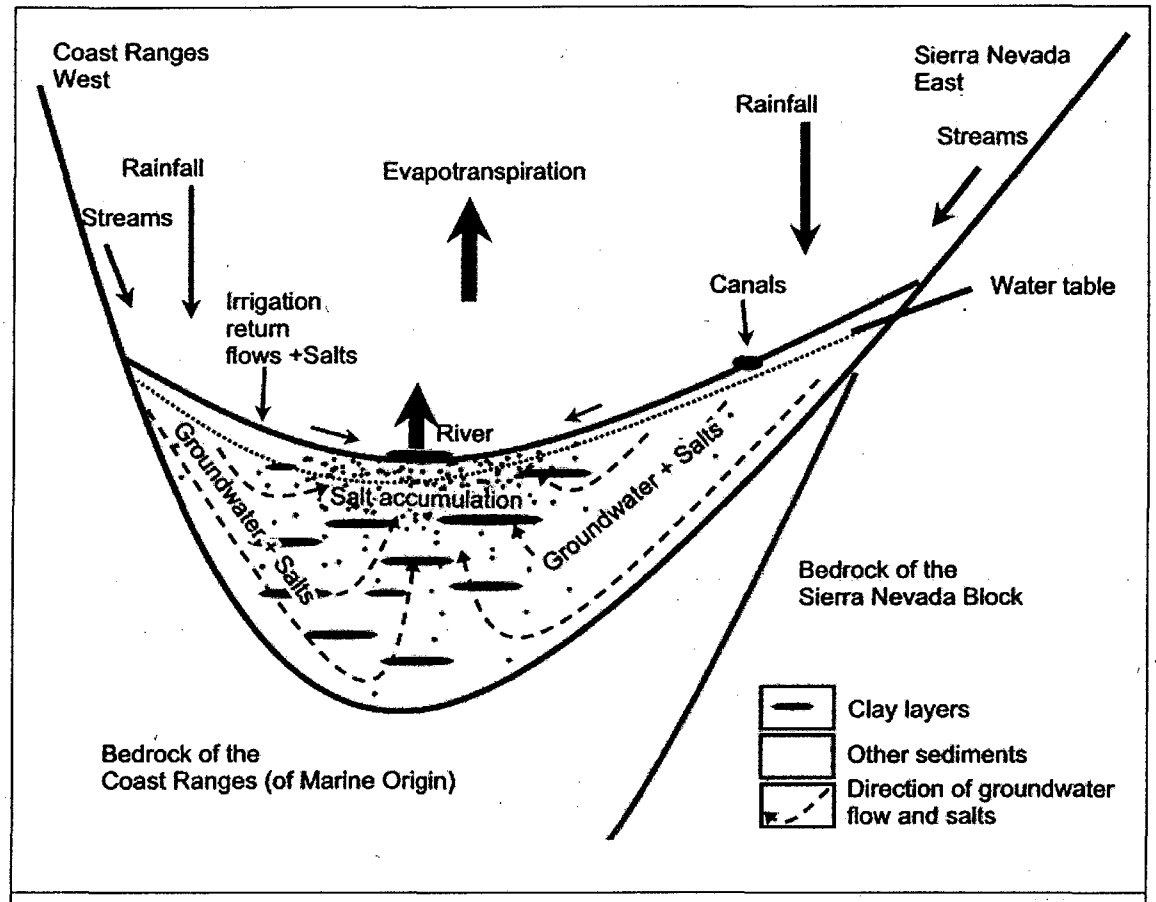

Figure 7: The Aquifer System of the San Joaquin Valley (not to scale)

A more detailed depiction of groundwater flow pattern is given in Figure 7. In this figure, the arrows show the movement of water as well as salts. As water moves from the recharge area to the discharge area, its chemical character undergoes profound changes. In the region of recharge, it is rich in oxygen and the water is very oxidizing in nature. As it moves away from the recharge area, it becomes depleted in oxygen and progressively more reducing. Below regions of discharge, groundwater tends to be anoxic and reducing in nature. This change in the oxidation state of groundwater governs the chemical ability of groundwater to dissolve chemical constituents from rocks and soils and precipitate them. In addition, water that resides for longer periods of time in the ground tends to become enriched in dissolved salts such as chlorides, sulfates, and nitrates of sodium, potassium, calcium, and magnesium.

In the arid SJV, groundwater that rises to the land surface does not get flushed out. This is because the only natural outlet to flush out discharge area groundwater is the San Joaquin River, which has only a limited capacity to flush out groundwater discharge. The consequence is that the major outlet for discharge area groundwater is evaporation. As water evaporates, salts are left behind. Thus, along the axis of the valley, there exists a gradual accumulation of salts in the wetlands, even without human intervention.

Aggressive, historical irrigation in the SJV has perturbed the natural flow system, and hence, the chemical quality of groundwater in significant ways. First, the application of water on agricultural lands forces water to infiltrate downward. This infiltration force, however, is opposed by the long-distance, long-time forces that push groundwater upwards in discharge areas. A consequence is water stagnation or waterlogging and the accumulation of salts near the land surface. Second, irrigation water imported by canals from the Sacramento basin area is highly oxidizing in nature. However, the in situ discharge area groundwater tends to be reducing. The mixing of these two waters of widely variable character profoundly affects water quality as well as soil quality. In the irrigated tracts of discharge areas, the chemical properties of soils will undergo progressive, irreversible changes.

Waterlogging has the effect of speeding salt accumulation because bare soil evaporation can take place, evaporating water directly from the water table. When the soil is saturated within five feet of the land surface, evaporation takes place at faster rates. Saturated conditions and high salinity decrease crop growth rates. The stagnation of flow also slows the process by which groundwater flow carries salt to surface streams, the only outlet for such salt.

There are other collateral effects. In areas where groundwater is pumped heavily from deep aquifers, the water pressures in aquifers will decline significantly. If the declines are sufficiently high, these aquifers will cease to push water up toward the land surface in discharge areas. Instead, contaminated water will be drawn down towards the deeper aquifer, impairing chemical quality at depth.

A second collateral damage is land subsidence. In the SJV, the aquifers are in general interbedded with clays and silts. These clays and silts are quite soft and compressible. Large-scale groundwater pumping and large declines in water pressure lead to drainage of water from the soft layers of silt and clay. This drainage causes the clays and silts to decrease in volume and the decrease in volume manifests itself as subsidence at the land surface.

a. The Pre-Development Flow System (Before 1920)

The first comprehensive studies of the SJV identified three distinct water-bearing units: (1) an unconfined and semi-confined zone of freshwater above the Corcoran Clay of the Tulare Formation, (2) a confined zone of freshwater beneath the Corcoran Clay, and (3) a saline layer of water underlying the freshwater. Deposits overlying the Corcoran Clay are derived from Coast Ranges to the west and the Sierra Nevada to the east.[61] The Coast Range materials, of marine origin, were found to be of lower permeability than the micaceous, Sierran materials.[62]

Despite the lack of continuous study, the groundwater flow has been examined at several points in time. The earliest known studies occurred early in agricultural

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[61] Davis, G. H., et al. (1957). Ground-water conditions in the Mendota-Huron area, Fresno and Kings Counties, California. Washington, D.C.: U.S. Government Printing Office.
Davis, G. H., et al. (1959). Ground-water Conditions and Storage Capacity in the San Joaquin Valley, California: Water Supply Paper 1469. Washington, D.C.: U.S. Geological Survey.
[62] Bull, W. B., et al. (1972). Land subsidence due to ground-water withdrawal in the Los Banos-Kettleman City area, California studies of land subsidence: Open-file report 72-57. Sacramento, CA: U.S. Geological Survey.

development.[63] During a period of intense exploitation several studies were completed that assessed the flow system.[64] Most recently, large-scale models have been built to reconstruct the flow regime before, during, and after agricultural development.[65] Several factors, both natural and anthropogenic, influence flow in the semi-confined and confined portions of the groundwater flow system.

Groundwater in the SJV moves from areas of recharge to areas of discharge, along a path of decreasing hydraulic head. Mean annual inflow to the SJHR by rivers is 9.7 cubic kilometers (7.9 MAF) and 4.1 cubic kilometers (3.3 MAF) to the TLHR.[66] Total precipitation falling in the entire watershed is 44 cubic kilometers (35.7 MAF) each year. Overall, stream channels gain about 0.37 cubic kilometers (0.3 MAF) per year from groundwater and lose 0.62 cubic kilometers (0.5 MAF) per year to groundwater.[67]

In the predevelopment flow system, recharge to west side groundwater came largely from the infiltration of stream water from streams. On the west side of the basin, this included intermittent streams such as the Little Panoche, Panoche, Cantua, and Los Gatos Creeks. None of these reached the San Joaquin River, but contributed approximately 0.04

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[63] Mendenhall, W. C. (1908). Preliminary report on the ground waters of the San Joaquin Valley, California: Water-supply paper no. 222. Washington, D.C.: U.S. Government Printing Office.
Mendenhall, W. C., et al. (1916). Ground water in San Joaquin valley, California. Washington,: Govt. Print. Off.
[64] Davis, G. H., et al. (1959). Ground-water Conditions and Storage Capacity in the San Joaquin Valley, California: Water Supply Paper 1469. Washington, D.C.: U.S. Geological Survey.
[65] Williamson, A. K., et al. (1985). Ground-water Flow in the Central Valley, California: OFR 85-345. Sacramento: U.S. Geological Survey.
Williamson, A. K., et al. (1989). Ground-water Flow in the Central Valley, California: P 1401-D. Reston, VA: U.S. Geological Survey.
[66] Department of Water Resources (1998). Bulletin 160-98: California Water Plan Update. Sacramento: State of California.
[67] Williamson, A. K., et al. (1989). Ground-water Flow in the Central Valley, California: P 1401-D. Reston, VA: U.S. Geological Survey.

cubic kilometers (0.035 MAF) per year to recharge (0.02 cubic kilometers or 0.015 MAF evaporate).[68]

On the east side, heavier precipitation-fed rivers such as the San Joaquin, Kern, Merced, and others existed. Deep percolation of precipitation upgradient of discharge areas was a significant source of recharge in wetter years. Throughout the entire valley, precipitation was 15.2 cubic kilometers (12.4 MAF or 11.6 inches/year) per year on average. Potential evapotranspiration was approximately 124 centimeters/year (49 inches/year) at the valley floor. Precipitation occurring in cooler months exceeded evapotranspiration, thereby contributing to groundwater recharge and surface runoff. This was reversed throughout the warmer months of the year, especially on the valley floor. The average rate of precipitation in excess of evapotranspiration was 1.8 cubic kilometers (1.5 MAF).

On the west side, soil-salinity and soil-compaction data support the inference that natural recharge occurred predominantly in areas crossed by intermittent streams.[69] This is based on the fact that soil salinities are highest in the midfan and distal-fan areas, places absent of intermittent streams. The lowest soil salinities are found in areas with major creeks. Further, soils subject to near-surface compaction due to the application of irrigation waters suggest that recharge due to infiltration was limited in these areas.[70] Therefore, it can be assumed that most recharge on the west side occurred at the fanheads.[71]

Discharge from the predevelopment groundwater system occurred largely through evaporation and streamflow in the lower reaches of the valley trough as shown in Figure 7.

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[68] Davis, G. H., et al. (1957). Ground-water conditions in the Mendota-Huron area, Fresno and Kings Counties, California. Washington, D.C.: U.S. Government Printing Office.
[69] Harradine, F. F., et al. (1950). Soils of western Fresno County, California. Berkeley, Calif.: University of California.
[70] Bull, W. B. and Department of Water Resources (1964). Geomorphology of segmented alluvial fans in western Fresno County, California. Washington D.C.: U.S. Geological Survey.
[71] Belitz, K., et al. (1990). Character and evolution of the ground-water flow system in the central part of the western San Joaquin Valley, California. Washington, D.C.: U.S. Geological Survey.

In the northern part of the valley, this discharge had only one exit through the San Joaquin and Sacramento River Delta. In the southern portion of the SJV, in the TLHR, much of the discharge was to Tulare Lake. Surveys around 1910 documented the presence of marshlands along much of the valley trough and artesian conditions.[72] At this time, water-table contours indicated the gradient to slope southwest to northeast at 0.3 to 1 meter (1 to 3 feet) per mile.

Vertical flow in the pre-development system was significant based on the presence of wetlands and free-flowing artesian wells.[73] There was (and still is) significant vertical leakage through the Corcoran Clay. Computer simulations of the predevelopment confined zone show similarities with the semi-confined zone. The gradient sloped in the same direction as in the semi-confined zone. Hydraulic heads were simulated to be typically 3 to 6 meters (10 to 20 feet) lower than the semi-confined zone along the Coast Ranges and 0 to 3 meters (0 to 10 feet) higher along the valley trough.[74]

b. Post-Development Groundwater System

Groundwater extraction for irrigation altered gradients of regional and local groundwater flow beginning as early as the late 1800s. Although these changes have been offset by the introduction of surface water deliveries to the region via the Central Valley and State Water Projects, the effects are still quite discernable.

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[72] Mendenhall, W. C. (1908). Preliminary report on the ground waters of the San Joaquin Valley, California: Water-supply paper no. 222. Washington, D.C.: U.S. Government Printing Office.
Mendenhall, W. C., et al. (1916). Ground water in San Joaquin valley, California. Washington,: Govt. Print. Off.
[73] Hall, W. H. and California. Office of State Engineer (1886). Physical data and statistics of California. Tables and memoranda relating to rainfall, temperature, winds, evaporation, and other atmospheric phenomena; drainage areas and basins, flows of streams, descriptions and flows of artesian wells, and other factors of water supply; mountain, valley, desert, and swamp-land areas, topography of stream channels, elevations above the sea, and other topographical features. Sacramento, CA: State of California.
[74] Williamson, A. K., et al. (1989). Ground-water Flow in the Central Valley, California: P 1401-D. Reston, VA: U.S. Geological Survey.

Irrigation was introduced to California around 1790.[75] The Gold Rush increased development in the SJV in the years following 1849, increasing the demand for irrigation waters. The Swampland District Reclamation Act in 1857 offered land patents to individuals willing to drain and reclaim lands for agriculture. This introduced an extensive system of canals and laterals to drain lands on the valley floor. Wetlands were reclaimed and flooding cycles were quelled. By as early as 1900, the entire flow of the Kern and Kings rivers in the TLHR had been diverted. By 1910, nearly all the surface water in the SJV had been diverted.

The drought of the 1880s and the lack of storage facilities sent farmers searching underground for water supplies for the long, dry summer months. The use of groundwater also allowed for the expansion of irrigation to areas at higher elevations on the valley flanks, distant from surface water supplies. The pressing necessity for lifting groundwater from depth for irrigation motivated the development of the deep-well turbine pump around 1910. The development of the deep-well turbine pump greatly increased the ability of irrigators to extract water supplies from the once-artesian wells, which had ceased to flow freely.

Recognizing the need for further storage and transport capacity, the state enlisted the financial backing of the federal government to construct the Central Valley project which began in the 1930s. The construction of Friant Dam on the San Joaquin River in 1942 helped provide for year-round water supplies for east-side farmers. Later, Shasta Dam on the Sacramento River was completed in 1945 along with the construction of the Delta-Mendota Canal to carry waters to the west side of the SJV. These projects helped offset groundwater extraction in areas with rights to or contractual agreements for delivered water.

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[75] Hall, W. H. and California. Office of State Engineer (1886). Physical data and statistics of California. Tables and memoranda relating to rainfall, temperature, winds, evaporation, and other atmospheric phenomena; drainage areas and basins, flows of streams, descriptions and flows of artesian wells, and other factors of water supply; mountain, valley, desert, and swamp-land areas, topography of stream channels, elevations above the sea, and other topographical features. Sacramento, CA: State of California.

However, although overdraft was reduced in portions of the SJV, increases in the application of imported water on the valley trough have artificially imposed recharge conditions in areas of regional discharge. As mentioned earlier, these and other developments have greatly altered the flow regime, with consequences for the transport of salts and other materials through the subsurface.

Increases in the irrigated acreage from 1870 to 1980 and the availability of surface water have changed the amount and proportion of groundwater consumed. In 1900, only a small portion of irrigation water was from groundwater. The combined capacity of wells south of Chowchilla increased from 6.5 cubic kilometers (5.3 MAF) per year in 1919 to 17.1 cubic kilometers (14.9 MAF) per year in 1929.[76] In 1948, the gross annual extraction in the SJV south of Merced was close to 7.3 cubic kilometers (6 MAF). In 1952, total diversion of surface water was 10.5 cubic kilometers (8.5 MAF) per year, while groundwater extraction was 9.2 cubic kilometers (7.5 MAF) per year.[77] Since most farms in the SJV are equipped to use both surface and ground water, the proportion of groundwater extracted tends to increase in dry years, when surface water deliveries are reduced.

c. Groundwater Chemistry

Groundwater temperature varies from 45° F to 105° F throughout the SJV. Some of the higher temperatures are attributable to the presence of thermal springs. Chemical composition varies greatly depending on its source, largely marine on the east side and micaceous on the west side. Recharge originating on the Coast Ranges is rich in sodium-

[76] Simpson, T. R. (1950). Development and utilization of ground water in California.
[77] Davis, G. H., et al. (1964). Use of ground-water reservoirs for storage of surface water in the San Joaquin Valley, California: Geological Survey water-supply paper 1618. Washington, D.C.: U.S. Government Printing Office.

calcium bicarbonate, whereas the Sierran side of the valley is largely sodium sulfate rich. Total dissolved solids (TDS) range from 50 to 10,000 mg/l.

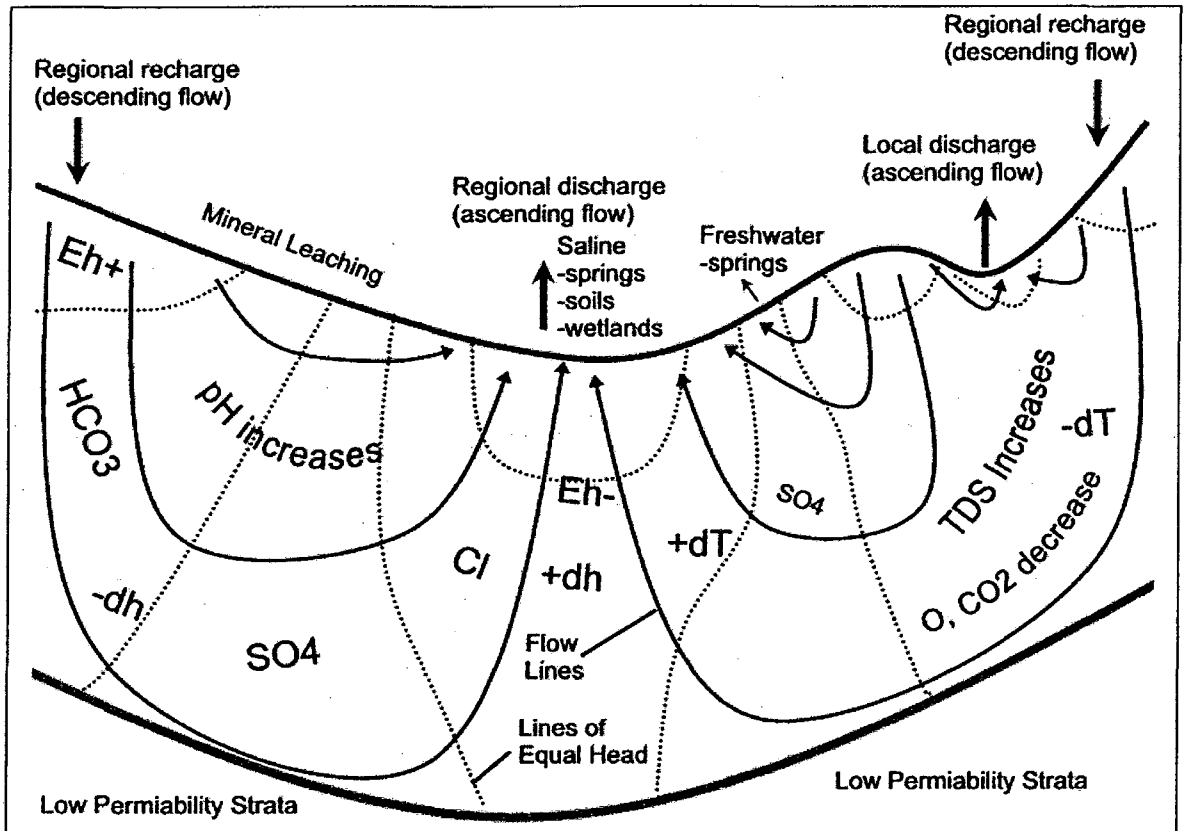

Figure 8: Effects of Flow on Groundwater Chemistry in a Conceptualized Unconfined Basin

The chemistry of the groundwater and soils of the SJV is dictated by the regional groundwater flow patterns. The conceptual frameworks of Toth[78] and Winter[79] are an appropriate basis for understanding the evolution of groundwater chemistry from areas of recharge to areas of discharge. As shown in Figure 8,[80] environmental effects and conditions arising from such a setting are:

[78] Toth, J. (1999). "Groundwater as a geologic agent: An overview of the causes, processes, and manifestations." Hydrogeology Journal 1999(7): 1-14.
[79] Winter, T. C. (2001). "The Concept of Hydrologic Landscapes." Journal of the American Water Resources Association 37(2).
[80] Adapted from Toth, J. (1999). "Groundwater as a geologic agent: An overview of the causes, processes, and manifestations." Hydrogeology Journal 1999(7): 1-14.

(1) Hydraulic heads decrease along flow paths from areas of recharge to areas of discharge;

(2) Dry soil moisture conditions in recharge areas (negative water balance) and water surplus in areas of discharge, often resulting in wetlands;

(3) Predictable evolution in dominant ions along flow paths, often from HCO_3^- through SO_4^{2-} to Cl^-, both along flow lines and with increasing depth;

(4) Chemical leaching of soils and near surface rocks in recharge areas and evaporative concentration of salts at flow system terminuses;

(5) Oxidizing conditions in areas of recharge, chemically reducing conditions in areas of discharge; and

(6) Accumulation of transported materials such as metallic ions and anthropogenic contaminants in areas of converging flow paths.

These conditions and the causative natural forces are all well documented in the SJV. However, most of the management authorities that were put in place in the early 20th century to allocate water do not operate in such a way that these forces are adequately accounted for. For example, the patchwork of irrigation districts throughout the valley is not based on hydrologic features. These districts also do not have the ability to coordinate activities at the scale at which the valley functions as a whole. The SJV's deep groundwater system supplies 30 percent of the salt load to the San Joaquin River.[81] Nutrient and pesticide contamination can be transported over great distances through an intermingled groundwater-surface water system.[82] These characteristics of large, arid basins as discussed by Toth support the conclusion that these systems must have coordinated management at a large scale.[83] Failure

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[81] Regional Water Quality Control Board-Central Valley Region and California Environmental Protection Agency (2002). Total Maximum Daily Load for Salinity and Boron in the Lower San Joaquin River. Sacramento: State of California.

[82] Bergamaschi, B. A., et al. (1997). Pesticides Associated with Suspended Sediments in the San Francisco Bay Estuary, California: Open-File Report 97-24. Reston: U.S. Geological Survey.

[83] Doneen, L. D. (1967). "Properties of Deep Substrate Materials in the West Side of the San Joaquin Valley, California." Hilgardia 38(9): 285-306.
Toth, J. (1995). "Hydraulic Continuity in Large Sedimentary Basins." Hydrogeology Journal 3(4): 4-16.
Toth, J. (1999). "Groundwater as a geologic agent: An overview of the causes, processes, and manifestations." Hydrogeology Journal 1999(7): 1-14.

to manage these systems at large scale will permit local users to externalize the costs of overexploitation and quality degradation onto other parties and further the "commons" problem.[84]

B. Land and Water Use Activities in the San Joaquin Valley

1. Water Supply and Water Use in the San Joaquin Valley

There are three major water users in the SJV: agriculture, municipalities, and the environment. In the SJHR, approximately 0.74 cubic kilometers (0.6 MAF) are used by urban areas, 4.2 cubic kilometers (3.4 MAF) are dedicated to environmental uses,[85] and 8.6 cubic kilometers (7.0 MAF) are consumed by agriculture.[86] Of this demand, approximately 10.7 cubic kilometers (8.7 MAF) are met by surface water supplies (some via interbasin transfer) and cubic kilometers 2.7 (2.2 MAF) are met by groundwater in normal years.[87] Population in the region is 1.6 million.

In the TLHR, approximately 0.8 cubic kilometers (0.7 MAF) are consumed by urban use, 2.1 cubic kilometers (1.7 MAF) by the environment, and 13.2 cubic kilometers (10.7 MAF) go to irrigate agricultural lands. This supply is divided between 9.7 cubic kilometers (7.9 MAF) from surface water and 5.3 cubic kilometers (4.3 MAF) from groundwater. Population in the region is 1.7 million. Applied irrigation waters are estimated to range

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[84] The development of groundwater basins presents many "commons" problems similar to those more broadly discussed in Hardin, G. (1968). "The Tragedy of the Commons." Science 162(1968): 1243-1248.
[85] "Dedicated" is used here within the meaning of California Water Plan, wherein environmental water use is defined as: dedicated flows in State and federal wild and scenic rivers; instream flow requirements established by water right permits, Department of Fish and Game agreements, court actions, or other administrative documents; Bay-Delta outflows required by SWRCB; and applied water demands of managed freshwater wildlife areas. By definition, environmental water use may not reflect minimum flows in a stretch of river. Environmental water use is a sum of all the dedications on a river, thus dedications at several points along a river may be counted and yield a total that is much higher than a minimum flow.
[86] Department of Water Resources (1998). Bulletin 160-98: California Water Plan Update. Sacramento: State of California.
[87] In dry years, surface water consumption decreases to 6.0 MAF and groundwater use increases to 2.9 MAF.

between 46 centimeters and 67 centimeters (18 and 26 inches) throughout much of the west side of the SJV.[88]

Of the surface water supply in the SJHR, approximately 1.7 cubic kilometers (1.4 MAF) are imported from the Sacramento basin into the basin via the Delta-Mendota Canal (Central Valley Project) and about 0.7 cubic kilometers (0.6 MAF) are transferred out of the basin via the Mokelumne, Hetch Hetchy, and other aqueducts. Of the surface water in the TLHR, approximately 1.5 cubic kilometers (1.2 MAF) originate from the SJHR via the Friant-Kern Canal. Another 2.9 cubic kilometers (2.4 MAF) are transferred via state and federal canals from the Sacramento watershed to the TLHR.[89]

2. Agriculture in the San Joaquin Valley

In the SJHR there are 8,000 square kilometers (2 million acres) of irrigated cropland and 13,350 square kilometers (3.3 million acres) in the TLHR. Row crops include various vegetables and some fruits, such as strawberries. Field crops generally include non-edible crops such as alfalfa, cotton, field corn, and sugar beets.[90] Agricultural statistics for the entire SJV are presented in Figure 9. These are comprehensive statistics for the counties of

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[88] Gronberg, J. A. M., et al. (1992). Estimation of a water budget for the central part of the western San Joaquin Valley, California. Sacramento: U.S. Geological Survey.

[89] Department of Water Resources (1998). Bulletin 160-98: California Water Plan Update. Sacramento: State of California. For additional information, see also Ogilbee, W., et al. (1969). Ground-water pumpage in Kern County, San Joaquin Valley, California, 1962-66. Menlo Park, CA: U.S. Geological Survey.
Mitten, H. T. and U.S. Geological Survey (1976). Estimated ground-water pumpage in parts of the San Joaquin Valley, California, 1969-71. Menlo Park: U.S. Geological Survey.
Mitten, H. T., et al. (1978). Estimated agricultural ground-water pumpage in parts of Fresno, Kings, and Madera counties, San Joaquin Valley, California, 1974-77: Open-file report 78-826. Menlo Park, CA.: U.S. Geological Survey.
Mitten, H. T. and Department of Water Resources (1980). Estimated agricultural ground-water pumpage in parts of the San Joaquin Valley, California, 1975-77: Open-file report 80-1281. Menlo Park, CA.: U.S. Geological Survey.
Gronberg, J. A. M., et al. (1990). Distribution of wells in the central part of the western San Joaquin Valley, California. Sacramento: U.S. Geological Survey.
Gronberg, J. A. M., et al. (1992). Estimation of a water budget for the central part of the western San Joaquin Valley, California. Sacramento: U.S. Geological Survey.

[90] Domagalski, J. L. (1992). Pesticides in Surface and Ground Water of the San Joaquin-Tulare Basins, California: Analysis of Available Data, 1966 through 1992: USGS Water-Supply Paper 2468: U.S. Geological Survey.

Fresno, Kings, Amador, Calaveras, Kern, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tulare, and Tuolumne.

Year	1987 Total	1992 Total	1997 Total
Farms (number)	33,664	31,353	30,110
Land in farms (acres)	11,716,931	11,220,957	10,872,323
Land in farms - average size of farm (acres)	6,363	6,607	6,355
Total cropland (farms)	28,912	26,912	26,037
Total cropland (acres)	5,558,382	5,423,449	5,558,460
Total cropland, harvested cropland (farms)	25,758	24,148	23,611
Total cropland, harvested cropland (acres)	4,289,683	4,416,063	4,610,750
Irrigated land (farms)	27,236	25,481	24,952
Irrigated land (acres)	4,401,654	4,417,004	4,941,628
Market value of agricultural products sold ($1,000)	7,119,036	8,714,765	11,919,064
Market value of agricultural products sold, average per farm (dollars)	2,386,235	3,060,741	4,178,154
Market value of ag prod sold - crops,incl nursery and greenhouse crops ($1,000)	4,539,638	5,542,857	8,044,902
Market value of ag products sold - livestock, poultry, and their products ($1,000)	2,579,398	3,164,894	3,874,165
Livestock and poultry: Cattle and calves inventory (number)	2,216,656	2,412,297	2,673,034
Beef cows (number)	300,166	283,113	297,073
Milk cows (number)	652,322	809,438	979,967
Cattle and calves sold (number)	1,365,797	1,460,002	1,663,740
Hogs and pigs inventory (number)	85,047	183,873	160,135
Hogs and pigs sold (number)	184,181	359,788	285,603
Sheep and lambs inventory (number)	354,339	292,669	300,167
Broilers and other meat-type chickens sold (number)	194,865,671	90,166,499	82,006,285
Wheat for grain (acres)	257,564	245,042	275,350
Barley for grain (acres)	110,143	88,869	47,811
Rice (acres)	31,922	23,784	24,798
Cotton (acres)	1,039,514	1,045,217	1,002,088
Hay-alfalfa,other tame,small grain,wild,grass silage,green chop,etc (acres)	656,845	687,105	783,769
Vegetables harvested for sale (see text) (acres)	315,776	360,073	446,808
Land in orchards (acres)	1,397,277	1,491,287	1,731,343

Figure 9: Agricultural statistics for San Joaquin Valley counties[91]

To maximize the productivity of agricultural lands, large amounts of nitrogen and phosphorus fertilizers are applied. Trends in the application rates of nitrogen fertilizer through time are displayed in Figure 10.[92] For the entire SJV, the average annual application of nitrogen fertilizer for years 1980-1985 was 307 million kilograms. Application rates increased more than ten-fold from 1945-1985. Given that there are approximately 22,300

[91] U.S. Department of Agriculture (1997). Census of Agriculture, Volume 1 Geographic Area Series: U.S. Department of Agriculture,.

[92] Alexander, R. B. and R. A. Smith (1990). County-level Estimates of Nitrogen and Phosphorus Fertilizer Use in the United States, 1945-1985: Open File Report 90-130. Reston: U.S. Geological Survey.

square kilometers (5.5 million acres) of cropland, application rates of nitrogen alone average approximately 140 kilograms/hectare (56 kilograms/acre) each year.

Additionally, pesticides are used at a high rate. In 1999, 56 million kilograms of active ingredient pesticides were applied over the SJV.[93] This amounts to approximately 25 kilograms/hectare (10 kilograms/acre) each year.

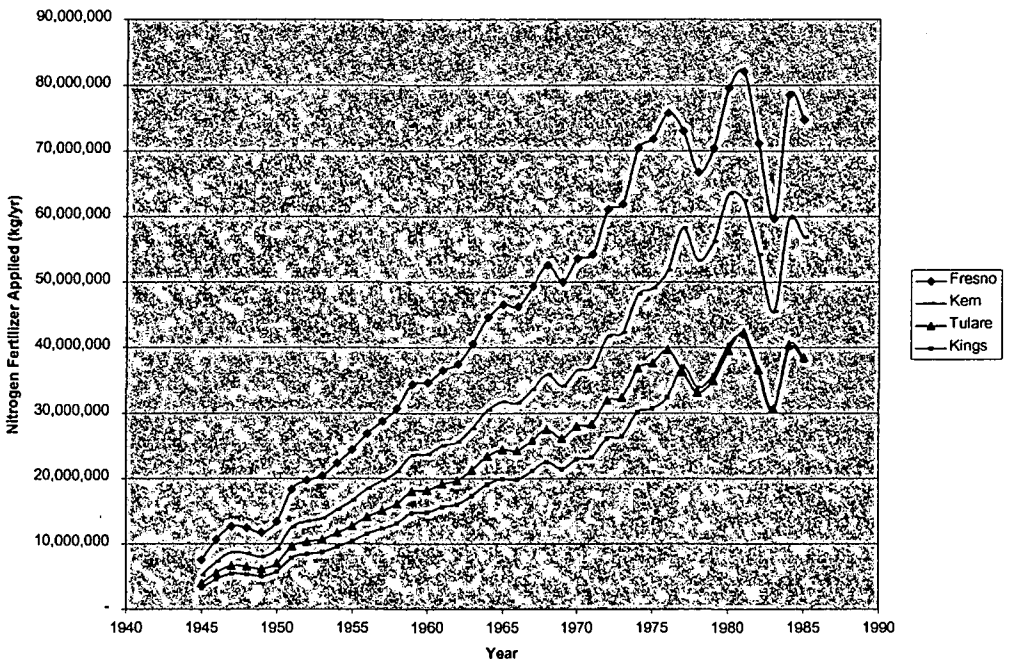

Figure 10: Trends in Nitrogen Fertilizer Application in the top 4 San Joaquin Valley Counties (kilograms/yr)

C. The State of the Groundwater System

1. Overdraft and Land Subsidence

The issue that draws the most attention when discussing groundwater problems in the SJV is overdraft. Overdrafting a basin is defined in many different ways but the definition used by DWR is, "the temporary condition of a ground water basin where the

[93] Department of Pesticide Regulation (1999). 1999 Annual Pesticide Use Report Preliminary Data: Fresno County Indexed by Commodity. Sacramento: California Environmental Protection Agency.

amount of water withdrawn by pumping exceeds the amount of water replenishing the basin over a period of time."[94] Although discussions have taken place for more than fifty years about the negative consequences of overdrafting groundwater,[95] most notably by DWR's Bulletin 118, the State Water Plan in 1998 still identified the SJV as a region of critical overdraft (along with several other basins in California). It is estimated that on average 1.8 cubic kilometers (1.5 MAF) of water per year are extracted above what is replenished.[96]

Overdrafting directly leads to increased pump lift costs and less water availability during drought periods. There are also several side effects, such as land subsidence (loss of storage capacity) and saltwater intrusion in some areas. Lowering the water table generally can have drastic effects on overlying vegetation, riparian areas, and wetlands.[97]

Subsidence in the valley began in the mid-1920s following the advent of high capacity, deep-well pumps. In 1942, approximately 3.7 cubic kilometers (3 MAF) were pumped each year, rising to 12 cubic kilometers (10 MAF) by 1970.[98] By 1970, 13,5000 square kilometers (5,200 square miles or 3.3 million acres) had been affected by subsidence up to 9 meters (28 feet) near Mendota. In 1968, deliveries of irrigation water from the SWP and CVP began to reduce the reliance on groundwater. As a result, the potentiometric head recovered up to 65 meters (200 feet) in some places.

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[94] Department of Water Resources (1975). Bulletin 118: California's ground water. Sacramento: State of California.

[95] Holsinger, H. (1939). Review of 'Selected problems in the law of water rights in the West'.
Holsinger, H. (1950). A brief summary of judicial history of water law in California.
Holsinger, H. and Department of Water Resources (1956). Required ground-water legislation: Department of Water Resources.

[96] Department of Water Resources (1998). Bulletin 160-98: California Water Plan Update. Sacramento: State of California.

[97] U.S. EPA, et al. (1996). An Assessment of the Ecological Impacts of Ground Water Overdraft on Wetlands and Riparian Areas in the United States: EPA 813-S-96-001: Idaho Water Resources Research Institute.
Danskin, W. R., et al. (1998). Evaluation of the hydrologic system and selected water-management alternatives in the Owens Valley, California: U.S. Geological Survey water-supply paper 2370. Denver, CO: U.S. Geological Survey.

[98] Department of Water Resources (1975). Bulletin 118: California's ground water. Sacramento: State of California.

Overdraft of groundwater is also tied to the overall water balance in the San Joaquin River. During drier periods, when surface water deliveries through the CVP and SWP are reduced, groundwater extraction greatly increases.[99] This reduces valuable base-flow to the river during periods of drought.[100] See Figure 11 for a historical record of flow in the San Joaquin River.[101]

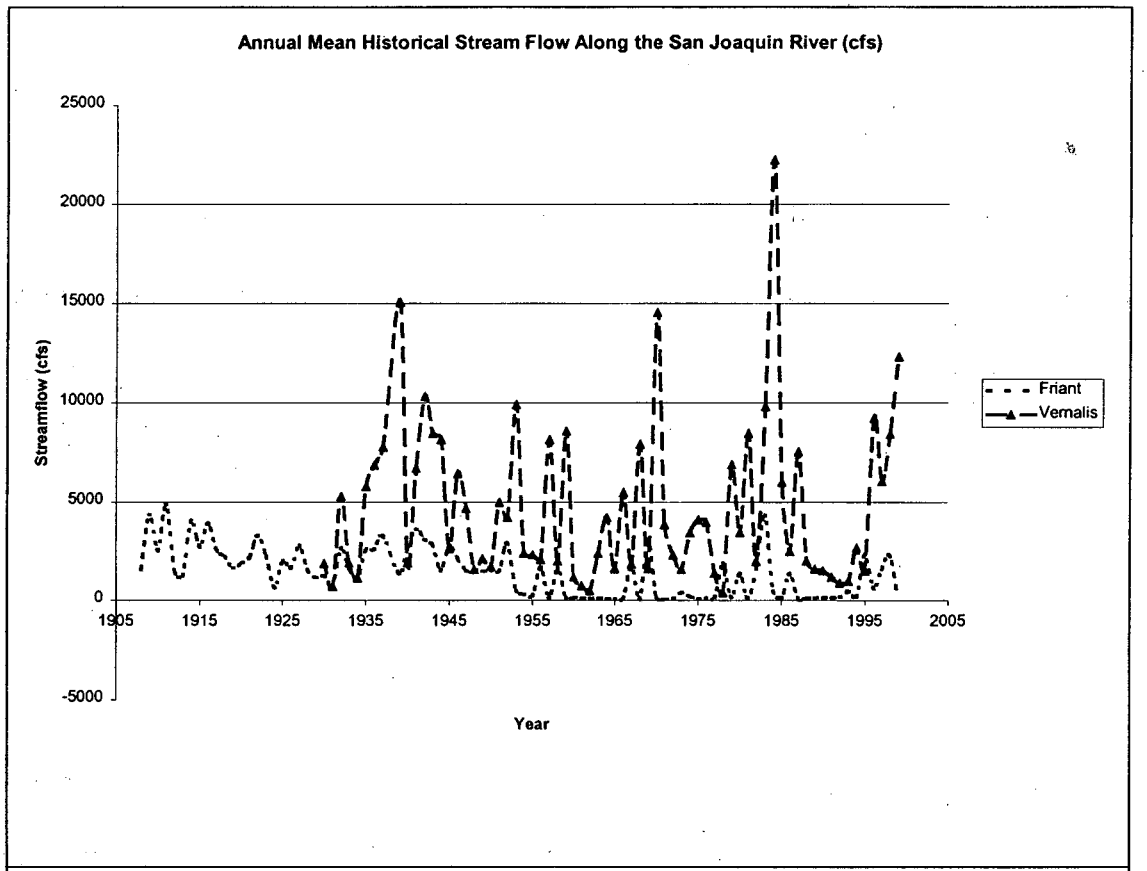

Figure 11: Average Annual Flow in the San Joaquin River

[99] Westlands Water District (2000). December 1999 Groundwater Conditions: Westlands Water District.
[100] Department of Water Resources (1998). Bulletin 160-98: California Water Plan Update. Sacramento: State of California.
[101] Department of Water Resources (2000). California Data Exchange Center. Internet: State of California, , http://www.cdec.ca.gov.

2. Water-logging, Salinity, Drainage, and Trace Elements

a. Overview

Waterlogging is a phenomenon largely associated with irrigation and poorly drained soils. Given that many agricultural crops grown throughout the SJV require nearly a vertical meter of water to meet their evapotranspirational requirements and that rainfall throughout most of the SJV is only 20 centimeters (8 inches) per year, the remainder must be made up by irrigation. This irrigation throughout much of the SJV is applied by furrow irrigation with relatively low irrigation efficiencies,[102] resulting in applied waters which leach pass the roots to accumulate in the sub-surface. Irrigation efficiencies on average range from 61 percent to 73 percent.[103] Further complicating waterlogging is the concentration of salts and trace elements (arsenic, boron, and selenium) in the shallow subsurface. These conditions exacerbate the deleterious effects on crops. Waterlogging also leads to bare soil evaporation where shallow groundwater can be directly evaporated (at depths typically less than 1.6 meters (5 feet), further concentrating salts and trace elements.

In parts of the west side of the SJV, salt accumulation threatens agricultural sustainability. Salt accumulation in the Grasslands subarea is reported as 0.45 metric tons/hectare-year (0.2 tons/acre-year).[104] The Westlands subarea reportedly adds 599,000 metric tons (666,000 tons) of salt per year, averaging 1.79 metric tons/hectare-year (0.8 tons/acre-year). Greater reliance on groundwater for irrigation in the Tulare subarea has caused salt accumulation to amount to 5.2 metric tons/hectare-year (2.3 tons/acre-year), the equivalent of 3,400,000 metric tons (1,500,000 tons) in total. The Kern subarea is increasing

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[102] Westlands Water District (2000). December 1999 Groundwater Conditions: Westlands Water District.
[103] Groundwater Management Technical Committee (1999). Task 6: Groundwater Management Final Report. Sacramento: The San Joaquin Valley Drainage Implementation Program.
[104] Groundwater Management Technical Committee (1999). Task 6: Groundwater Management Final Report. Sacramento: The San Joaquin Valley Drainage Implementation Program.

salt loads in the semi-confined zone at a rate of 2.0 metric tons/hectare-year (0.9 tons/acre-year). Overall, DWR estimates that 726,000 and 1,810,000 metric tons (800,000 and 2,000,000 tons) of salt are imported to the SJHR and TLHR, respectively each year[105]. Approximately, 320,000 metric tons (350,000 tons) leave the SJHR via the Delta each year and virtually no salt leaves the TLHR.

b. Impacts on Agriculture, Domestic Supplies, and the Environment

Mass importation of salt has increased ion concentrations in the soil and groundwater of the SJV to varying degrees, depending on characteristics of the soil, drainage practices, irrigation water source, and other factors. An example of groundwater conditions for salinity near Mendota is shown in Figure 12.[106]

Salinity in groundwater and soil limits water uptake in the root zone and can lead to significant losses in agricultural productivity.[107] Additionally, disposal costs of drainage water

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[105] Department of Water Resources (2001). Water Facts #20: Salt Balance in the San Joaquin Valley. Sacramento: State of California.

[106] From California Department of Water Resources, San Joaquin District (2001).

[107] For an excellent overview of salinization, see Ghassemi, F., et al. (1995). Salinisation of land and water resources : human causes, extent, management and case studies. Wallingford: CAB International..
Gilliom, R. J., et al. (1989). Preliminary assessment of sources, distribution, and mobility of selenium in the San Joaquin Valley, California. Sacramento, CA: U.S. Geological Survey.
Presser, T. S., et al. (1990). Geologic sources, mobilization, and transport of selenium from the California Coast Ranges to the western San Joaquin Valley : a reconnaissance study: Water-resources investigations report 90-4070. Menlo Park, CA: U.S. Geological Survey.
Laudon, J. and K. Belitz (1991). "Texture and Depositional History of Late Pleistocene-Holocene Alluvium in the Central Part of the Western San Joaquin Valley, California." Bulletin of the Association of Engineering Geologists 28(1): 73-88.
Gronberg, J. A. M., et al. (1992). Estimation of a water budget for the central part of the western San Joaquin Valley, California. Sacramento: U.S. Geological Survey.
Leighton, D. A., et al. (1992). Spatial distribution of selenium and other inorganic constituents in ground water underlying a drained agricultural field, western San Joaquin Valley, California. Sacramento: U.S. Geological Survey.
Fio, J. L., et al. (1994). Effects of ground-water chemistry and flow on quality of drainflow in the western San Joaquin Valley, California. Sacramento, CA: U.S. Geological Survey.
Fio, J. L., et al. (1994). Calculation of a water budget and delineation of contributing sources to drainflows in the western San Joaquin Valley, California: Open-file report 94-45. Sacramento, CA: U.S. Geological Survey.
Groundwater Management Technical Committee (1999). Task 6: Groundwater Management Final Report. Sacramento: The San Joaquin Valley Drainage Implementation Program.
On the West side of the San Joaquin Valley alone (2.3 million acres), a study of data from 1980-5 estimated that 6.1 million tons of salt are added to the semi-confined zone each year. This amounts to 2.8 million tons from

will increase. This situation is becoming particularly acute as the SWRCB implements the salinity and boron total maximum daily load (TMDL) as required under the federal Clean Water Act.[108] Dischargers will be required to reduce drainage to the San Joaquin

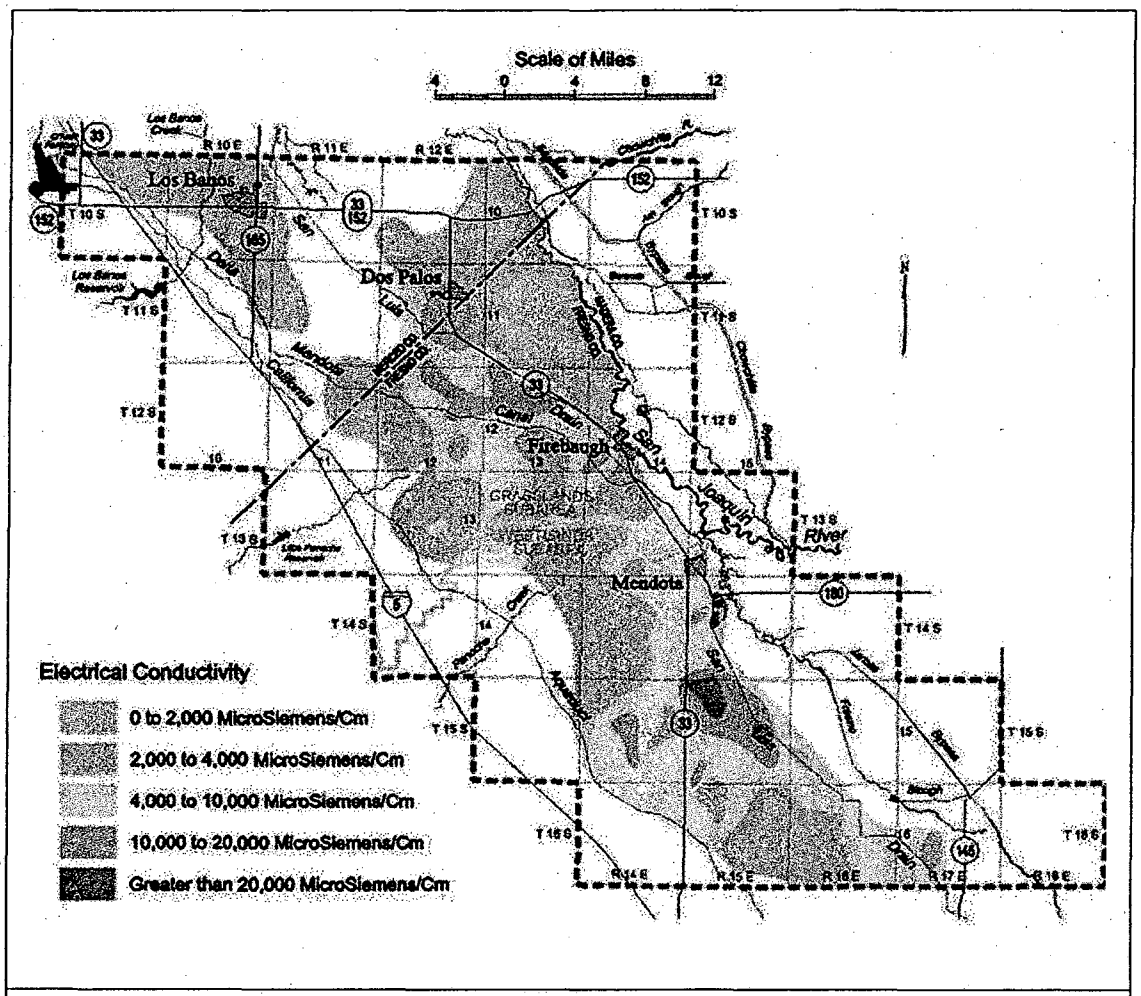

Figure 12: Electrical Conductivity of the Shallow Groundwater Near Dos Palos and Mendota, 2001[109]

salt solubilization, 1.7 from water imports from the Delta, 1 from the confined aquifer, 0.3 from local stream diversions, 0.2 from lateral and local stream inflow, and 0.1 from canal losses and precipitation San Joaquin Valley Drainage Implementation Program and University of California. Salinity/Drainage Task Force (2000). Final report : evaluation of the 1990 drainage management plan for the westside San Joaquin Valley, California. Sacramento: Department of Water Resources..

[108] 33 USC Sec. 1313 Water quality standards and implementation plans

River.[110]

Salinity is also a major problem for drinking water supplies. Although few studies have been done to characterize the cost on treatment operations, salt decreases the life span of most treatment facilities.[111] In many instances it also decreases water planning flexibility if fresher water must be mixed with higher concentration salts to provide potable water.

Although trace element concentrations do not directly affect agricultural operations (except in high concentrations), selenium, boron, and arsenic concentrations in drainage effluent can have a significant impact on environmental quality and drinking water.

Selenium toxicity at Kesterson reservoir is one of several trace element water quality problems left unresolved after nearly two decades of research into possible solutions.[112] The incident arose when, in 1971, the 134 km long San Luis Drain was terminated at a series of shallow regulating ponds, later known as Kesterson Reservoir, to collect waters from many of the subsurface drains installed along the west side of the SJV to mitigate water-logging (original plans to terminate the drain at the San Francisco Bay were amended because of insufficient funds). The United States Bureau of Reclamation (USBR) constructed this reservoir, which was later incorporated into the national wetlands system. Initially Kesterson received some fresh water flows, but by 1982 inflow consisted solely of saline water from subsurface drains, high in trace elements and pesticides. As early as 1981, ranchers in the vicinity noticed livestock abnormalities and death. They questioned USBR's operating practices and a rancher, James Claus, filed suit and a complaint with the SWRCB. In 1983, a

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109 Adapted from the Department of Water Resources.
110 Regional Water Quality Control Board-Central Valley Region and California Environmental Protection Agency (2002). Total Maximum Daily Load for Salinity and Boron in the Lower San Joaquin River. Sacramento: State of California.
111 Umali-Deininger, D. (1993). Irrigation-induced salinity : a growing problem for development and the environment. Washington, D.C.: World Bank.
112 Letey, J., et al. (1986). An Agricultural Dilemma: Drainage Water and Toxics Disposal in the San Joaquin Valley: 3319. Oakland: University of California.

large die-off of birds alerted the United States Fish and Wildlife Service (USFWS) officials to the toxicity of the reservoir.

On February 5, 1985, after a series of evidentiary hearings, the SWRCB ordered USBR to revise operating procedures within 6 months or close Kesterson. At the federal level, the U.S. House Subcommittee on Water and Power Resources met in Los Banos to investigate Kesterson's toxicity and USBR's involvement on March 15, 1985. During the meeting, the California representative of the Department of the Interior, Carol Hallet, announced that USBR was going to shut down the reservoir and stop water deliveries to 170 square kilometers (42,000 acres) of farmland in the Westlands Water District. This alarmed farmers who depended on the water for irrigation and later USBR decided to continue deliveries, phase out Kesterson, and plug all the drains. This process was completed in May of 1986. No final solution to agricultural drainage exists today and the majority of drainage water in the SJV, approximately 0.092 cubic kilometers (0.075 MAF) is at some point discharged into the San Joaquin River (aside from a few evaporation ponds in operation in the region).

In response to litigation, in April 2001, USBR filed with the United States District Court in Fresno a plan of action to provide drainage to the San Luis Unit. Under the court's order, USBR must act promptly to provide drainage service to the San Luis Unit. The plan of action provides that USBR will evaluate the economic feasibility and the environmental impacts/benefits of all viable drainage alternatives to support a decision on how to provide drainage service to the drainage-affected irrigated lands in the San Luis Unit.

3. Nonpoint Source Pollution (Pesticides and Nutrients)

The United States Geological Survey's (USGS) National Water Quality Assessment, conducted in the late 1980s and early 1990s, identified other sources of contamination to groundwater in the form of pesticides and nutrients.[113] The study focused on pesticide and nutrient levels under various agricultural practices and found many areas of contamination. These areas often also serve as drinking water supplies for private well owners and municipalities.

Under the Clean Water Act, California is required to identify surface waters that are impaired as defined by the Clean Water Act. In the SJV, the San Joaquin River is listed as impaired for boron, chlorpyrifos, DDT, Diazinon, electrical conductivity, group A pesticides, and selenium.[114] The Kings River is listed as impaired for electrical conductivity (EC), molybdenum, and toxaphene. Mine drainage in the form of mercury, copper, and zinc afflicts many of the waterways of the Sierran foothills such as the Mokelumne River. Portions of the Merced, Stanislaus, and Tuolumne Rivers are also listed for agricultural pollution.

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[113] Domagalski, J. L. (1992). Pesticides in Surface and Ground Water of the San Joaquin-Tulare Basins, California: Analysis of Available Data, 1966 through 1992: USGS Water-Supply Paper 2468: U.S. Geological Survey.
Dubrovsky, N. M., et al. (1995). Water Quality in the San Joaquin-Tulare Basins, California, 1992-95: USGS Circular 1159: U.S. Geological Survey.
State Water Resources Control Board, et al. (2000). A Compilation of Water Quality Goals. Sacramento, CA: The Board.
[114] State Water Resources Control Board (1999). California 303(d) List and TMDL Priority Schedule 1998. Sacramento: State of California.

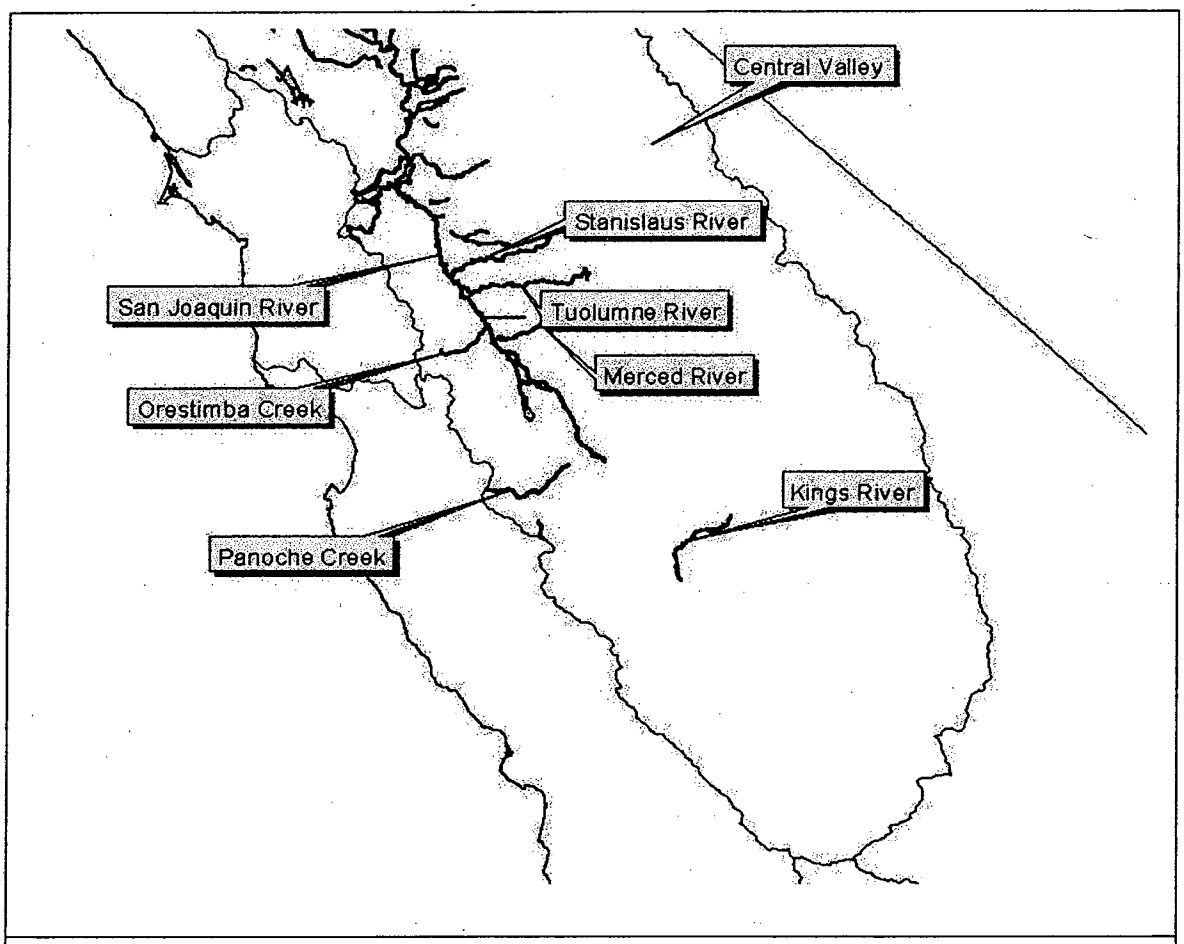

Figure 13: Major Water Bodies Listed as "Impaired" Under § 303(d) of the Federal Clean Water Act

These nonpoint sources[115] of contamination are a threat to drinking water supplies that rely on groundwater and the San Joaquin River Delta, and have been shown to impact flora and fauna.[116] California has thus far not looked at the connections among groundwater, soil, and surface water quality. Consequently, institutions that are needed to address these problems optimally do not exist. The quantity of nutrients and pesticides applied is not controlled, despite very small marginal returns with increases in application

[115] According to USEPA, "Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water."

[116] Kratzer, C. R. (1999). "Transport of sediment-bound organochlorine pesticides to the San Joaquin River, California." Journal of the American Water Resources Association 35(4): 957-981.

rates.[117] These issues will be of primary importance as California seeks to implement the United States Environmental Protection Agency's (USEPA) mandated Drinking Water Source Assessment and Total Maximum Daily Load programs. Figure 13 shows waters listed as impaired under the Clean Water Act.[118]

4. Point Source Pollution (Industrial and Urban Discharge)

Point source pollution is less of a threat to groundwater quality in the valley as a whole in comparison to nonpoint source pollution. However it should be noted that there are several Superfund sites within the valley. These sites, along with underground storage tanks, represent a localized threat to groundwater supplies. This aspect of groundwater contamination is more regulated than others through both federal and state law.

D. Findings

Over the past several decades, scientific advances in the field of hydrogeology have led to several important conclusions about the nature of groundwater. First, groundwater is hydrologically connected with surface water. Second, groundwater chemistry and flow have a large impact on soil chemistry, particularly in arid regions. Third, groundwater processes take place at large spatial and temporal scales. These findings indicate that groundwater management practices that developed absent this knowledge may be inappropriate.

Groundwater in the SJV is influenced by climate, physiography, geology, and the impact of human activities in the valley. After more than 100 years, extraction of groundwater from the confined zone, particularly along the west side of the valley, has taken place at a rate greater than that at which it is replaced. The resulting condition of overdraft

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[117] Dinar, A., et al. (1994). Irrigated agriculture and environmental pollution : lessons from the Westside San Joaquin Valley, California. Washington, D.C.: U.S. Department of Agriculture.
[118] State Water Resources Control Board (1999). California 303(d) List and TMDL Priority Schedule 1998. Sacramento: State of California.

has altered patterns of discharge in the valley. Wetlands and artesian wells, indicative of a zone of discharge, have disappeared along the axis of the valley. The reduction in discharge to the San Joaquin River has decreased the amount of salt transported out of the valley. Thus, the rate of accumulation of salts and trace elements in the shallow groundwater system has increased.[119]

Pumping from the lower confined zone and irrigation with large volumes of water have reversed the flow of groundwater and helped facilitate the downward migration of salts and other near surface contaminants. This increased rate of salt accumulation is hastened by the importation of high TDS waters from the Delta region for irrigation and the extraction, in time of need, of low quality groundwater.

The over-allocated nature of the San Joaquin River has eliminated most prospects of using the river's assimilative capacity to transport minerals out of the northern portion of the valley. State regulation of San Joaquin River water quality has led to restrictions on the amount of agricultural drainage products that can be transported to the river via the San Luis Drain and other tributaries. Although on-farm solutions have helped protect river quality, they have encouraged the in-basin storage of salts. The storage of salts in surface water ponds leads to additional leaching to the groundwater system. This adds to the problem of subsurface tile drains, predominant on the west side of the valley, that intermingle saline drainage products with groundwater. The failure of the SWRCB to integrate surface water policies with their resulting effects on the groundwater system has encouraged practices detrimental to groundwater quality (see Figure 14 for an overview of groundwater-related issues in the SJV).

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[119] Orlob, G. T. (1998). Chapter 8: San Joaquin Salt Balance: Future Prospects and Possible Solutions. The Economics and Management of Water and Drainage in Agriculture. A. Dinar and D. Zilberman. Boston, Kluwer Academic Publishers: 143-167.

Increases in groundwater salinity have a detrimental impact on agricultural, domestic, and environmental uses of water throughout the valley. Increased salinity decreases crop productivity, requiring increased drains, increased irrigation frequency/quantity to remove salts, and increased facilities to dispose of the salts.[120] Eventually lands may have to be abandoned. Despite modern technology, the present-day SJV is subject to the same constraints as those experienced by Mesopotamians, Hohokum indians, and inhabitants of the Indus Valley in present-day Pakistan.

Studies have shown that even modest increases in water salinity can greatly increase the costs associated with filtering for domestic consumption. In drinking water filtration and distribution systems, salinity decreases the life of machinery through increased corrosion and wear. Salinity levels above 500 milligrams/liter are also unpleasant in drinking water (although most states and USEPA have set this only as a voluntary limit).

A coordinated policy to protect water in large basins such as the SJV must incorporate not only surface water, but also the groundwater and soil systems that are tied to the overall health of the system. For agriculture to continue to be successful in the valley, consideration must be given to the long-term soil and groundwater quality. These considerations should also take into account the needs of groundwater supply and quality to support an increasing population dependent upon groundwater in the valley. The ultimate challenge in the SJV is one of assessing the extent to which the groundwater-soil-land infrastructure can support long-term agriculture and to set in place institutions and strategies to achieve it.

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[120] San Joaquin Valley Drainage Implementation Program (1998). Drainage Management in the San Joaquin Valley: A Status Report. Sacramento, CA: The Program.

Figure 14: Table Summarizing Some of the Major Water Quality and Quantity Issues in the San Joaquin Valley and the Impacts to Agricultural, Municipal, and In-stream (Environmental) Uses.

	Impact to:		
Alteration	**Agriculture**	**Municipal**	**In-stream**
Reduction in stream flows	Reduce the assimilative capacity.	Reduce the assimilative capacity.	Reduce the assimilative capacity, flow might be insufficient for fish passage, temperature might increase.
Reduction in groundwater	Increased pump costs, subsidence.	Increased pump costs, subsidence.	Reduction of stream recharge and native vegetative cover due to a lowering of the water table, as in the Owens Valley.
Subsidence	Reduced aquifer storage capacity, building damage.	Reduced aquifer storage capacity, building damage.	Reduced stream recharge in dry periods.
Pesticides		Drinking water quality may not meet Safe Drinking Water Act standards, e.g. pesticide contamination such as DBCP.	Bioaccumulation in food web, sensitive species of macro-invertebrates, fish, and birds may suffer health effects.
Nutrients		Nitrate levels do not meet Safe Drinking Water Act standards in many regions of the Central Valley.	Eutrophication (decreased dissolved oxygen given increased algal growth and decomposition).
Salinity	Salinity of applied water and resident groundwater can stress plants and reduce yields. West side of the San Joaquin Valley is highly susceptible due to poorly drained soils.	Dramatically increased purification costs	Overlying species may be adversely affected by areas with saline shallow groundwater. Bare soil evaporation may continue to increase salinity even in fallowed or retired lands.
Trace elements			Toxic to waterfowl, livestock, and aquatic life.
Sediment erosion	Soil loss can lead to long-term declines in agricultural productivity.	Increased turbidity can compromise disinfection. High organic carbon in the chlorination process can lead to carcinogenic Trihalomethanes.	Negative impact to spawning fish species.

Chapter III. Groundwater Law and Management in California

Groundwater law in California has evolved from a series of common law cases from England and the United States, complemented at times by actions of the California State Legislature. The contributions of common law to the current system of groundwater law and management include the doctrines of:

- absolute ownership (English rule of capture),
- reasonable use,
- correlative rights, and
- prescriptive rights.

The California State Legislature has added some very important aspects of groundwater management by establishing the constitutional amendment, Article X, § 2 requiring all uses of water to be reasonable and beneficial; [121] by including pragmatic elements in the CWC (e.g. well registration and studies of groundwater basins); and by creating avenues for administrative agencies to actively control groundwater (e.g. AB 3030, groundwater management districts, and special water districts).

Although the common law and acts of the California State Legislature have intermingled, case law has largely fashioned groundwater management in California. The courts themselves have reflected upon the inherent limitations of imposing policy on water management from the bench on several occasions.[122] The resulting system of law has resulted in much confusion in groundwater law, including: the quantity of the entitlement,

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[121] Article 10, §2. 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 waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters 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.

[122] *In re Determination of Rights to Waters of Long Valley Creek Stream System* (1979). 25 Cal.3d 339.
United States of America v. State Water Resources Control Board (1986). 182 Cal.App.3d 82.

priority in times of shortage, priority between agencies of private and public character, interbasin transfers and management, and priority between agencies of different water uses. These uncertainties have been exacerbated by a lack of information collection and analysis. Even basic data about the level of groundwater extracted is not required of users nor uniformly collected by agencies. Lastly, there has been an absence of legal mechanisms for groundwater users in a basin to collectively manage groundwater by limiting production to reduce overdraft or allocate water to more beneficial uses. Although AB 3030 could have been a proactive statute, the failure of the state to require plans in overdrafted basins and other areas of concern has not helped to overcome the serious collective action problem that exists when attempting to manage a resource that is distributed among many individuals.

This chapter reviews the evolution of groundwater law in California in relation to surface water law and examines the tools currently available to manage the state's groundwater.

A. Legal History of Judicial and Legislative Actions in Groundwater

Until the signing of the Treaty of Guadalupe Hidalgo in 1848, present-day California was under Mexican law.[123] In the vast uninhabited areas of Alta California (the present-day California region), the Mexican government granted water on the public domain for use on the agricultural settlements of pueblos. Thus, these settlements were granted pueblo rights to use water from adjacent public lands as necessary. These were the only vested water rights carried over to the United States upon signing of the treaty. In 1850, California was admitted to the Union and by statute adopted the common law of England where consistent

[123] Strauss, J. D. and G. H. Murphy (1956). California Water Law in Perspective.

with the United States Constitution. The common law of England included the doctrine of riparian rights for surface water and the doctrine of absolute ownership[124] for groundwater.

Subsequent to California statehood, common law traditions dictated that riparian rights—the right of an owner of land adjacent to a body of water to use that water— (in addition to pueblo rights) constituted the only mechanism for acquiring "new" rights in water. With the discovery of gold on public lands in 1848, a new system of acquiring rights on public land, similar in part to pueblo rights and known as appropriation water rights, gained importance. Miners rarely held title to the land and required large volumes of water for hydraulic mining in which cannons of water were aimed at soft alluvial deposits to create a slurry to sluice out gold. Additionally, ranchers and other water users on the public domain also needed a way of obtaining water rights. Appropriation rights set up a system by which use of water denoted ownership, regardless of land ownership. Priority became the most important factor in this rights process leading to the phrase: "First in time, first in right."

As early as 1853, California courts recognized right to appropriated water on public land.[125] This was followed in 1872 by a state statute[126] identifying appropriations of water so long as record was made of the diversion or taking possession of the water with the county recorder.[127] In 1879, the state declared ownership of water in Article X, § 5 of the California Constitution: "The use of all water now appropriated, or that may hereafter be appropriated,

[124] Also herein referred to as the Rule of Capture or English Rule.
[125] Early California case law recognizes both prior appropriation and riparian rights by applying priority to disputes between appropriators and by applying riparian principles to disputes between riparians.
[126] California Civil Code §1415.
[127] The United States officially recognized appropriation rights by Act in 1866 and riparian rights in 1870.

for sale, rental, or distribution, is hereby declared to be a public use, and subject to the regulation and control of the state, in the manner to be prescribed by law."[128]

In the first major case regarding groundwater in California, the California Supreme Court applied the English Rule of capture to California in Hanson v. McCue (1871).[129] This rule was unilaterally applied, except in cases where there was "malicious intent to wantonly deprive" adjacent property owners. This ruling followed the English Court in the case of Acton v. Blundell (1843).[130] This case before the Court of Exchequer Chamber in England found that percolating groundwater was attached to the soil and therefore any well drilled on one's property that incurred injury on neighboring land owners was without remedy. The court further stated that groundwater "falls within the principle which gives to the owner of the soil all that lies beneath its surface; that the land immediately below is his property, whether it is solid rock, or porous ground, or veinous earth, or part soil, part water."

The rising dominance of appropriation rights was checked in 1886 in the California Supreme Court decision of Lux v. Haggin (1886).[131] The California Supreme Court recognized the doctrine of riparian rights, finding that riparian rights attach to riparian land when it becomes private property and, while subject to the priority of earlier appropriations on public lands, the riparian rights were paramount to subsequent appropriations. The court stated, "Every proprietor of lands through or adjoining which a water course passes has a

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[128] Former Const Art XIV § 1, as adopted May 7, 1879, amended June 6, 1972. Also as CWC § 102.
[129] *Thomas H. Hanson v. James S. McCue* (1871). 42 Cal. 303; 1871 Cal. LEXIS 202. Perhaps the earliest application of the English Rule to the United States was in the Ohio case of *Frazier v. Brown* (1861), 12 Ohio St. 294. The opinion noted the "occult nature" of groundwater and found that exploiting groundwater to the extent of dewatering the wells of neighbors was an injury without remedy (except incases where the intent was to wantonly deprive the neighbor). In 1984, the Supreme Court of Ohio revisited this rule, overrule it, and applied correlative right principles of Tort law *Cline v. American Aggregates Corporation* (1984). 15 Ohio St. 3d 384..
[130] *Acton v. Blundell* (1843). 12 Mees. & W. 324, 354, 152 Eng. Rep. 1223, 1235 (Ex. Ch. 1843).
[131] *Lux v. Haggin* (1886). 69 Cal. 255.

right to a reasonable use of water, but he has no right to so appropriate it as to unnecessarily diminish the quantity of its natural flow."

In 1887, the California Legislature passed the Wright Irrigation District Act,[132] the state's first comprehensive enabling act for water district organization. Voting for directors in irrigation districts was based on one vote for each registered voter.

The court in Harris v. Harrison (1892),[133] held that in times of water shortage, all riparians must adjust water use to allow for an equal sharing of the available water supply. This system of correlative rights was later applied to groundwater. The Supreme Court of California in Katz v. Walkinshaw (1903) applied this riparian doctrine to underground waters.[134] The decision held that overlying owners had "equal and correlative rights" in the use of water for overlying lands and that use by an owner for overlying lands is preeminent to use for non-overlying lands. The court stated about the English Rule: "The field is open for exploitation to every man who covets the possessions of another or the water which sustains and preserves them, and he is at liberty to take that water if he has the means to do so, and no law will prevent or interfere with him, or preserve his victim from attack." Although the case called for correlative rights between overlying users, all appropriated uses were secondary to overlying uses. This was particularly problematic for municipal water companies who were typically considered appropriators. In times of drought, appropriators under Katz would be required to cut back their consumption back to zero before any overlying users would be required to curtail production.

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[132] Toward the end of the 19th century, this irrigation district movement was resisted by owners of large properties. Their response was the California Water District Act of 1913. In districts authorized by this act, voting was weighted by property; one vote for each dollar's worth of land Goodall, M. (1991). Water in California agriculture. Water in California Agriculture: Technology, Politics, and People, Sacramento..
[133] *Harris et al. v. Harrison et al.* (1892). 93 Cal. 676.
[134] *Katz v. Walkinshaw* (1903). 141 Cal. 116.

Montecito Valley Water Co. v. Santa Barbara (1904) defined classes of groundwater. Surface water rights are applied to the first two categories of groundwater (underflow and groundwater flowing in well-defined channels), while distinct groundwater laws are applied to percolating waters, which include water in underground water basins, and groundwaters that have escaped from streams.[135] Nearly fifty years after recognizing appropriation rights to surface water, San Bernardino v. Riverside (1921) recognized the right to appropriate groundwater.[136] Any water not needed for the reasonable and beneficial use of those having prior rights is surplus water and may be appropriated on privately owned land for non-overlying use, such as dedication to public use or use beyond the basin or watershed. The case also found that public agencies stand in the character of an appropriator (overlying rights do not apply), thus public agencies might be found junior to private landowners with overlying rights. The current system is similar to the California doctrine approach to surface water. Owners of overlying land have a correlative right to make reasonable use of groundwater. Following the ruling in California Water Service Co. v. Edward Sidebotham & Sons, Inc. (1964), this right is paramount to the right of groundwater appropriators.[137]

In 1913 the Legislature of California passed the Water Commission Act, creating the State Water Commission and codifying procedures for the appropriation of water.[138] Little else changed until the case of Herminghaus v. Southern California Edison Company (1926).[139] This case held that a riparian owner was entitled to the full flow of a stream without regard to reasonableness against appropriators, finding the doctrine of reasonable use only applied between riparian owners. This holding induced the California State

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[135] *Montecito Valley Water Company v. City of Santa Barbara* (1904). 144 Cal. 578.
[136] *City of San Bernardino v. City of Riverside* (1921). 186 Cal. 7; 198 P. 784; 1921 Cal. LEXIS 409.
[137] *California Water Service Co. v. Edward Sidebotham & Son* (1964). 224 Cal. App. 2d 715; 1964 Cal. App. LEXIS 1519; 37 Cal. Rptr. 1.
[138] CWC § 1200
[139] *Herminghaus et al. v. Southern California Edison Co. et al.* (1926). 200 Cal. 81.

Legislature to pass an amendment to the Constitution of California in 1928,[140] limiting the right of riparian owners to water reasonably acquired for beneficial use. This principle has been applied to groundwater as well.

From 1920 onward, much of the Central Valley and California experienced excessive overdraft. Advances in well-pump technology, combined with increasing irrigated acreage, resulted in a large increase in groundwater extraction. In order to meet demand, projects were conceived to supplement water supplies of the Central Valley and Southern California.

Improvements in dam building technology in the 1920s and 1930s provided state leaders with a comprehensive solution to coordinate water resources throughout the state. In 1933 the California Legislature adopted a plan for transfer of water from the Sacramento River and northern California to the water-deficient areas of the SJV through construction of a Central Valley Project. Shasta Dam was to store waters of the Sacramento River and Friant Dam, on the western edge of the Sierra, was to divert water from the San Joaquin River to southern regions of the valley. Various other units were also designed to transfer water from the Sacramento River system to the SJV. However, given unfavorable economic

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[140] Article X, Section 2: Water resources; Riparian rights
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 waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters 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 right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonble method of use or unreasonable method of diversion of water. Riparian rights in a stream or water course attach to, but to no more than so much of the flow thereof as may be required or used consistently with this section, for the purposes for which such lands are, or may be made adaptable, in view of such reasonable and beneficial uses; provided, however, that nothing herein contained shall be construed as depriving any riparian owner of the reasonable use of water of the stream to which the owner's land is riparian under reasonable methods of diversion and use, or as depriving any appropriator of water to which the appropriator is lawfully entitled. This section shall be self-executing, and the Legislature may also enact laws in the furtherance of the policy in this section contained.

conditions, the state turned to the federal government to finance and construct the project.[141]

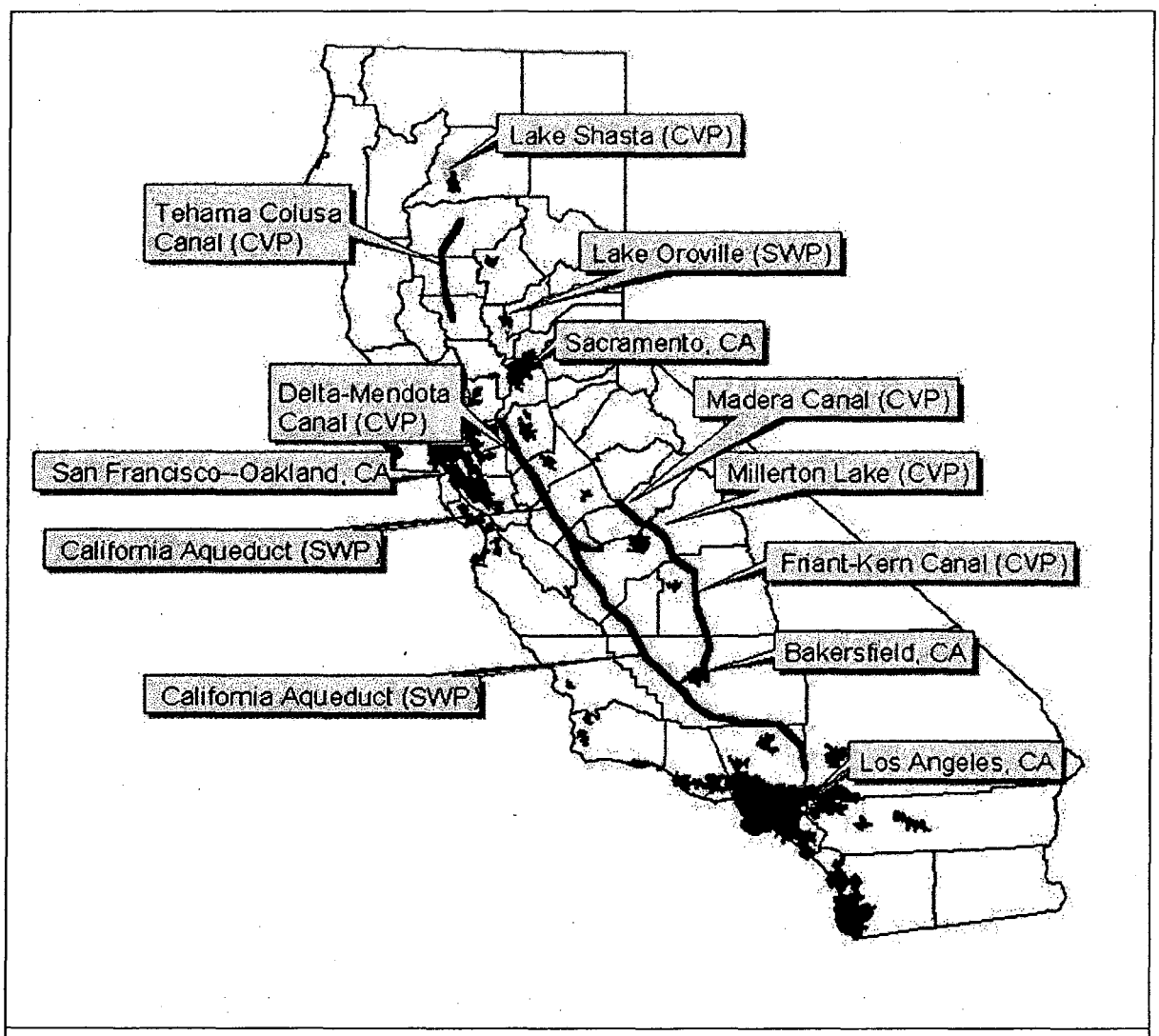

Figure 15: Major Central Valley Project and State Water Project Facilities

Construction of the CVP began in 1937. It is now one of the world's most extensive water transport systems (see Figure 15). Shasta Dam began storing water and generating electric power in 1944. The waters of the Sacramento River which flow past Shasta Dam are augmented by additional water supplies brought through a tunnel from the Trinity River and

[141] Department of Water Resources (1979). The California Water Atlas. California: State of California.

from reservoirs formed by Folsom and Nimbus Dams on the American River. About 48 kilometers (30 miles) south of Sacramento, the Delta Cross Channel regulates the passage of Sacramento River water through the Delta to the Tracy Pumping Plant.

At Rock Slough, a portion of the water is pumped into the Contra Costa Canal for municipal uses in Contra Costa County. At the Tracy Pumping Plant, the water is lifted nearly 65 meters (200 feet) above sea level into the Delta Mendota Canal and flows 188 kilometers (117 miles) southward to the Mendota Pool. Here, the waters from the north augment the natural flow of the San Joaquin River. At Friant Dam, the flow of the San Joaquin River is impounded and diverted through the Friant-Kern Canal 245 kilometers (152 miles) south to the southern reaches of the SJV.

Following World War II, state authorities renewed their efforts to develop a comprehensive statewide water plan, one that recognized the increasing urban demand. In 1951 the Legislature authorized the Feather River and Sacramento-San Joaquin Delta Diversion Project and in 1957 authored the first California Water Plan. This Feather River and Sacramento-San Joaquin Delta Diversion Project — the SWP— began operations in 1967 under management of the DWR. Water from the Feather River is stored behind Oroville Dam and is released into the Feather River and its eventual confluence with the Sacramento River. The greatest portion of water is lifted into the California Aqueduct for transport through the SJV and eventually again lifted by a series of pumping stations over the Tehachapi Mountains for use to southern California. Although the CVP was almost exclusively constructed for agricultural water use, the SWP dedicates a large portion of its contracted supply to urban water use.

Although the projects were designed to improve water supply throughout the SJV and other parts of California, the new supply increased growth and demand in arid regions of the state, renewing conflicts. High variability in annual water deliveries via the projects led to an increased reliance on groundwater in drought years, resulting in continued overdraft of many basins throughout California.

City of Pasadena v. City of Alhambra (1949) eliminated priorities between appropriators and riparians via prescripted rights in overdrafted basins.[142] The court found that rights to use water were based upon the pumping history of the previous five years. The quantification of these rights is usually accomplished through a court adjudication of the basin. All parties in the suit (all groundwater adjudications are initiated by a lawsuit) must submit to a physical solution[143] that quantifies all the groundwater rights of parties named in the suit.

Although the decision was aimed at reducing overdraft by apportioning cutbacks among all users, the approach had several drawbacks that hindered realization. First, a "race to pumphouse" resulted for basins that had not yet been adjudicated. Many groundwater users attempted to increase their use since stipulated shares would be allocated based on the quantity consumed over the past five years. This also led parties in overdrafted basins to wait longer to go to court and reach a stipulated solution, so that each could maximize his extraction.

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[142] *City of Pasadena v. City of Alhambra* (1949). 33 Cal.2d 908. Also referred to as the Mutual Prescription Doctrine.

[143] Physical solutions are a court decreed method (via judgment) of managing groundwaters in an adjudicated basin so as to achieve the maximum utilization of the basin and its water supply, consistent with the adjudicated water rights.

Second, the mutual prescription method is also limited because in order for the agreement to be binding, parties must be involved in an adversarial court proceeding. Simply negotiating a solution will not make it compulsory.

Third, the situation was complicated by the lack of information needed to make determinations such as: the beginning of the period of overdraft, the boundaries of the "basin," and accurate measurements of extraction. These data were neither collected by state agencies nor required of local groundwater users. However, the legislature responded to Pasadena by requiring groundwater users in four southern California counties to file notices of extraction with SWRCB.

The next step was the California Supreme Court ruling in City of Los Angles v. City of San Fernando (1975),[144] a decision that refined the application of the mutual prescription doctrine of City of Pasadena v. City of Alhambra. Los Angeles filed suit against cities and private landowners to condemn title to water underlying the Upper Los Angeles River Area. The court, interpreting §1007 of the California Civil Code, found that such prescripted rights[145] could not be acquired against public agencies, such as municipal water districts. In addition, owners would likely not be compensated for cutbacks and overlying owners retained a portion of their original rights and did not gain new prescriptive rights. Further, they found the prescriptive period begins only when actual notice of adverse extraction is given to the affected parties, not simply when the basin is in a state of overdraft.

The decision introduced the idea of equitable apportionment, which allows the courts flexibility in resolving disputes, granting them the power to set the safe yield for a

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[144] *City of Los Angeles v. City of San Fernando et al.* (1975). 14 Cal.3d 199.

[145] Prescripted rights are based on the common law theory of adverse possession. This theory holds that prescripted rights are acquired when one groundwater user extracts groundwater adversely to the rights of another groundwater user. In order for prescripted rights to be recognized, the adverse use must be notorious and continue for a period of five years.

given basin. One way of implementing this equitable apportionment was through the implementation of a "physical solution." This physical solution could involve introducing surface water supplies to supplement needs, providing one of the first mechanisms for interrelating surface water and groundwater management in California. Despite this progress, this idea of equitable apportionment has been effectual only in small confined basins where surface water can be used to replenish water to the safe yield level.[146] In 1978, the Governor's Commission to Review Water Rights Law recommended a statewide groundwater policy. However, none of the Commission's recommendations have been implemented.

In re Determination of Rights to Waters of Long Valley Creek Stream System (1979),[147] the court was asked to determine whether or not future (unexercised) rights to surface water could be limited. The court held that the SWRCB has the authority to limit future riparian rights in a stream system adjudication under CWC § 2501 and, citing Meridian Ltd. v. San Francisco,[148] remarked "We have recognized that there is a limitation inherent in the ability of private lawsuits to provide clarity, certainty, and security to water rights and water users. This method of resolving controversies involving the rights of the users of water on the river is necessarily piecemeal, unduly expensive and obviously unsatisfactory."

The same question was posed for groundwater in Wright v. Goleta Water District (1986).[149] The court was asked to determine whether a trial court, in a judicial adjudication of a ground water dispute among private parties and public entities, might define or limit future groundwater rights of an overlying owner who has not yet exercised those rights. The

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[146] Blomquist, W. and U.S. Geological Survey (1988). The performance of institutions for groundwater management. Bloomington, Indiana: Workshop in Political Theory & Policy Analysis Indiana University.
[147] *In re Determination of Rights to Waters of Long Valley Creek Stream System* (1979). 25 Cal.3d 339.
[148] *Meridian Ltd. v. The City and County of San Francisco* (1939). 13 Cal. 2d 424; 90 P.2d 537; 1939 Cal. LEXIS 269.
[149] *Martha H. Wright v. Goleta Water District* (1986). 174 Cal. App. 3d 74; 1985 Cal. App. LEXIS 2725; 219 Cal. Rptr. 740.

appellate court found that the trial court had erred in limiting future, unexercised rights in groundwater and reversed.

Judge Racanelli noted that many flaws in California's water law system were at issue in the case United States v. SWRCB (1989).[150] He recalled a passage from the book Water for California: Planning, Law & Practice, Finance stating, "The statewide coordinated development of California's water resources poses many complex legal problems. These problems are further complicated by: inadequacies and uncertainties of present state statutes generally; available procedures for acquisition of water rights; the nature and extent of vested rights in the use of surface and ground water; preferential rights of areas in which water originates; questions of the effectiveness of contract rights in assuring deficient areas of a dependable water supply; and questions of relations between the state and other agencies."[151] The case was brought to determine whether the State of California can establish standards for the operation of the federal CVP to protect water quality in the Bay-Delta region. The court ruled that the State of California can establish water quality standards. This case was a driving force in the behind the signing of the Bay-Delta Accord and the formation of the CALFED Bay-Delta Program.

In 1992, the California State Legislature passed AB 3030, California's attempt to introduce the concept of a "Groundwater Management Plan." The federal government, after recognizing the importance of groundwater in regional water planning, required AB 3030 plans for all CVP contractors with the passage of the Central Valley Project Improvement Act (CVPIA) of 1992. These amendments also increased allocations for in-stream water uses in the operation of the Central Valley Project. Although a plan needs to

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[150] *United States of America v. State Water Resources Control Board* (1986). 182 Cal.App.3d 82.
[151] Rogers, H. E. and A. H. Nichols (1967). Water for California: planning, law & practice, finance. San Francsco: Bancroft-Whitney.

be developed, the CWC does not specify what an AB 3030 groundwater plan must contain. The result is that few of the AB 3030 plans authored in response to the CVPIA contain substantive components.

In Baldwin v. Tehama (1994),[152] the court was asked to determine whether the State of California had preempted the field of groundwater law, thus barring counties from passing groundwater regulations.[153] On appeal, the court held that state law has not preempted the field of groundwater management. Accordingly, counties have reserved authority to pass regulations under the CWC.

Adjudication was revisited in 2000 in the case of Barstow v. Mojave.[154] In this case the court was asked to determine whether priorities can be eliminated and water apportioned equitably in a basin adjudication. The court found that the basin adjudication must include a full analysis of water rights and incorporate these into the physical solution. The decision eliminates the ability of adjudications to equitably apportion water in basins experiencing critical overdraft. The decision will likely be unfavorable to public agencies, whose rights will always be considered secondarily to private landowners.

The relationship between the state government and groundwater was at the heart of an insurance case, State of California v. Underwriters at Lloyd's of London (2000).[155] Therein the court was asked whether the state government should be the responsible party in a groundwater contamination case under the "owner exclusion" principle.[156] In determining whether an insurance company must pay out to a party that contaminated

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[152] *Peter Baldwin v. County of Tehama* (1994). 31 Cal. App. 4th 166.
[153] *Peter Baldwin v. County of Tehama* (1994). 31 Cal. App. 4th 166.
[154] *City of Barstow v. Mojave Water Agency* (2000). 23 Cal. 4th 1224.
[155] *The State of California v. Underwriters at Lloyd's of London* (2000). 78 Cal. App. 4th 1019.
[156] Owner exclusion is often a clause in insurance contracts that says they will not cover damages to property owned by other parties.

groundwater the underwriters attempted to apply an "owner exclusion" principle to the suit. Arguing that if the state owns all the groundwater underneath the insured's property then there is no obligation to pay the insured, the court interpreted sections of the CWC regarding state "ownership" and found that the state owns the water in a regulatory sense, not in a civil code sense of property.

B. The Concept of Groundwater Management

Groundwater management in California evolved from a need to reduce the uncertainty associated with private rights to extract the resource. Most of the principles discussed above focus on mechanisms for balancing limitations of the resource in a correlative fashion for overlying users and through a priority mechanism for appropriative users on non-overlying land. By most accounts,[157] existing mechanisms have only been somewhat successful in meeting this most basic of management goals. However, a much broader concept of management, that which includes (1) the protection of public interests in water, (2) in-stream uses within the meaning of § 1601 of the California Fish and Game Code, and (3) groundwater quality protection within the meaning of SWRCB Resolutions 68-16 and 88-63 clearly does not exist. Thus, California is faced with the task of transititioning groundwater institutions from a goal of economic development of the resource to a goal of protection of the long-term quality and quantity as required under current law. To help understand this transition, an overview of existing groundwater management institutions follows.

Management to protect the quality and quantity of groundwater takes place on many levels through public and private institutions. Individual well users undertake some

[157] See generally Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission..

management in planning, since excessive pumping will reduce water levels and increase pumping costs. Where the well is a source of drinking water, overlying landowners typically exercise care in handling hazardous materials. While the individuals in this sense have an option to protect the resource, their individual goals in utilizing the resource often differ from long-term public interests. More important, while the benefits of overexploitation inherently benefit the pumper, the costs of such overexploitation are shared among all users that are hydrologically connected.

Given that groundwater is a common pool resource, the marginal benefits to an individual to exploit will often exceed the marginal cost to himself. Given this fact it makes sense that users that share common interests might stand to gain something from collective management of the resource, such as reducing nutrient loads or overdraft. There exist several types of authority spread among several federal, state, and local agencies in California that regulate or manage some aspect of groundwater quality and quantity. Here are describe some of the major agencies involved, their powers, and critique the inherent shortcomings of many of these approaches.

1. Methods of Groundwater Management under Current California Law

There are approximately five ways for groups of groundwater users to come together and manage groundwater to preserve quality or quantity.[158] Since the SWRCB does not

[158] Department of Water Resources (1996). Water Facts #2: 7 Steps for Managing Groundwater Supplies. Sacramento: State of California.
Department of Water Resources (1996). Water Facts #3: Adjudicated Groundwater Basins in California. Sacramento: State of California.
Department of Water Resources (1996). Water Facts #4: Groundwater Management Districts or Agencies in California. Sacramento: State of California.
Department of Water Resources (2000). Water Facts #8: Groundwater Management in California--Six Methods Under Current Law. Sacramento: State of California.

recognize its authority over groundwater,[159] management of groundwater has fallen to districts, court appointed watermasters, counties, cities, and in some cases, special groundwater management districts. Each of these approaches has some positive aspects as well as drawbacks. The disadvantages largely stem from the piecemeal approach that California has taken to managing a complex resource. The authority of each type varies somewhat although they each share several shortcomings that will be discussed below.

a. Statutory Authority of Special Water Districts

There are 22 kinds of districts or local agencies with specific statutory provisions to manage surface water and/or groundwater identified in the CWC. These districts were largely created to facilitate the distribution of water, the best example being the Wright Irrigation District Act of 1887. Each of these districts has authority under the CWC to promulgate regulations that further the interest of the district. Although these regulations could impose pump taxes or best management practices for fertilizer applications, no such actions have taken place on any scale. At the same time, the geographic regions which these districts overlie have often experienced conditions of overdraft and groundwater contamination, leading to the conclusion that this method has not been very effectual to date in protecting groundwater. Good examples of this method are the Water Conservation District[160] and the Water Replenishment District Acts.[161]

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[159] Sax, J. L. (2002). Review Of The Laws Establishing The SWRCB's Permitting Authority Over Appropriations Of Groundwater Classified As Subterranean Streams And The SWRCB's Implementation Of Those Laws. Sacramento: State Water Resources Control Board.

[160] CWC §§ 74000-76501; "Water Conservation District Law of 1931." Purposes: Conserve and store water by dams, reservoirs, ditches, spreading basins, sinking wells, sinking basins, etc.; appropriate, acquire and conserve water and water rights for any useful purpose; obtain water from wells; sell, deliver, distribute or otherwise dispose of water; make surveys; provide recreational facilities; provide flood protection (§§ 74520-74541). May reclaim sewage and storm waters (§ 74593); may construct and operate hydroelectric facilities (§§ 74510-74511).

[161] CWC §§ 60000-60449; "Water Replenishment District Act (1955)." Purposes: Replenish groundwater supplies of the district (§§ 60220, 60221, 60230); protect groundwater from contaminants (§§ 60224-60226, 60318).

As an example, the Water Replenishment District of Southern California (WRD) manages groundwater replenishment and water quality activities of the Central and West Coast Basins (CWCB).[162] Their stated primary goal is to maintain a sufficient supply of high quality groundwater in the basins through progressive, cost effective, and environmentally sensitive management. WRD activities include standards and programs relating to water quality, water supply, basin management, stakeholder communications, and organizational operation. A major aspect requires understanding current groundwater conditions in the CWCB and predicting future conditions. This is achieved through groundwater monitoring, modeling, and planning to help characterize the state of groundwater in CWCB. This information is also distributed to the pumpers in the district, other interested stakeholders, and the public to help improve management and planning.

b. Adjudicated Groundwater Basins

Some California groundwater basins have been adjudicated to quantify rights to groundwater in a basin and to set a schedule of priorities to determine who must reduce pumping in times of shortage. The adjudication process is started by the filing of a lawsuit by one of the groundwater users in the basin. The goal of the suit is to define the extent of the correlative rights of each groundwater user. In contrast to statutory surface water adjudications initiated by the SWRCB, groundwater adjudications are only binding to parties listed in the suit, not all users in the basin. SWRCB authority to initiate groundwater adjudications is limited to "a subterranean stream flowing through known and definite channels" as defined by CWC § 2500.

[162] Water Replenishment District of Southern California (2001). Regional Groundwater Monitoring Report Central And West Coast Basins Los Angeles County, California Water Year 1999-2000. Cerritos.

After a lawsuit is initiated to adjudicate a groundwater basin, the court decides the groundwater rights of all the overliers and appropriators. The court decides who the extractors are, how much groundwater those well owners can extract, and who the watermaster will be. The watermaster ensures that the basin is managed according to the court's decree and reports periodically to the court. There are 18 adjudicated groundwater basins in California.

The usefulness of this method was severely limited by City of Barstow v. Mojave Water Agency where the ability the court to implement a physical solution that equitably apportioned water was eliminated.[163] There are few applications of this method to groundwater quality protection. One exception exists in the San Gabriel Basin where, in 1991, the watermaster was granted additional authority to limit extraction to protect the quality of groundwater. The following (Figure 16) provides a listing of adjudicated basins in California.

Figure 16: Adjudicated Groundwater Basins[164]	
1944—Raymond Basin	1973—Main San Gabriel Basin
1958—Cucamonga Basin	1977—Warren Valley Basin
1961—West Coast Basin	1978—Chico Basin
1965—Central Basin	1979—Upper Los Angeles River Area
1966—Santa Margarita River Watershed	1980—Scott River Stream System
1969—San Bernardino Basin	1985—Puente
1972—Cummings Basin	1996—Santa Paula Basin
1973—Tehachapi Basin	1996—Mojave Basin

c. Groundwater Management Districts

The California Legislature has passed special laws creating groundwater management districts or agencies in certain regions of the state. These agencies have typically been

[163] *City of Barstow v. Mojave Water Agency* (2000). 23 Cal. 4th 1224. For an excellent analysis of the situation in the Mojave Basin see Blomquist, W. and U.S. Geological Survey (1988). The performance of institutions for groundwater management. Bloomington, Indiana: Workshop in Political Theory & Policy Analysis Indiana University.

[164] Department of Water Resources and C. J. Hauge (1999). Groundwater management in California: a report to the Legislature pursuant to Senate Bill 1245 (1997). Sacramento, CA: State of California.

formed in densely populated areas where domestic water use constitutes the principal water use. These districts have powers that vary based on the wording of the legislation by which they were created. Powers are typically limited to pump taxes and extraction limits.

These districts have typically exercised the most comprehensive forms of water management within a basin. The monitoring of ambient groundwater conditions, extraction monitoring, allocation mechanisms, pump taxes, water quality, and an integration of surface and groundwater are all taken into planning considerations within many of California's Groundwater Management Districts.[165] The legislative acts endowed broad authority to the districts, removing the jurisdictional barriers that are frequently present in basins due to overlapping boundaries and authorities. The features of the Orange County Water District Act pertaining to district powers are given below:[166]

> 6. For the common benefit of the district and for the purpose of managing the groundwater basin and managing, replenishing, regulating, and protecting the groundwater supplies within the district to exercise the following powers:
>
> (a) Provide for the conjunctive use of groundwater and surface water resources within the district area.
>
> (b) Store water in underground water basins or reservoirs within or outside of the district.
>
> (c) Regulate and control the storage of water and the use of groundwater basin storage space in the groundwater basin within the district and pursuant to the provisions set forth in § 2.1 to (1) determine the amount of storage space available in the groundwater basin within the district, (2) allocate that available groundwater storage space, and (3) enter into groundwater storage agreements, provided that the district shall have no authority under the provisions of this section, except the provisions of paragraph (l) of this subdivision, to limit the extraction of groundwater within the district, except to the extent that a party may agree thereto under any such groundwater storage or other agreement.
>
> (d) Appropriate and acquire water and water rights within or outside of the district.
>
> (e) Purchase and import water into the district.
>
> (f) Conserve and reclaim water within or outside of the district.

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165 Orange County Water District (1999). Master Plan Report.
166 Section 2, Part 6 of the Orange County Water District Act.

(g) Buy and sell water at such rates as shall be determined by the board of directors.

(h) Exchange water.

(i) Distribute water to persons in exchange for ceasing or reducing groundwater extractions.

(j) Transport, reclaim, purify, treat, inject, extract, or otherwise manage and control water for the beneficial use of persons or property within the district and to improve and protect the quality of the groundwater supplies within the district.

(k) Fix the terms and conditions of any contract under which owners or operators of water-producing facilities within the district may agree to use water from an alternative nontributary source in lieu of groundwater, and to that end the district may become a party to such a contract and may pay from district funds that portion of the cost of water from an alternate source as will encourage the purchase and use of the same in lieu of producing groundwater, as long as persons or property within the district are directly or indirectly benefited by the resulting replenishment.

(l) Fix the terms and conditions of any contract under which the owner or operator of a water-producing facility within the district may agree to increase the production of groundwater in lieu of water from an alternative nontributary source for the purpose of removing contaminants or pollutants from the groundwater basin. The district may become a party to that contract and may pay from district funds that portion of the cost of the groundwater production as will encourage the production for beneficial use of polluted or contaminated groundwater, as long as that pollution or contamination is impairing the quality of the water supplies within the district and the quality of the water supplies within the district will be improved by that production.

(m) Determine in the manner herein provided the amount and percentage of water produced from the groundwater supplies within the district to the total amount of water produced within the district by all persons and operators, including the total amount of water from supplemental sources; require that persons and operators produce more or less of their total water needs from the groundwater within the district than the basin production percentage determined by the district as provided herein; levy a basin equity assessment, which may be uniform or nonuniform in amount as determined by the board of directors of the district, on each person and operator who produces more water from the groundwater within the district; and to compensate other persons and operators who are directed by the district to produce less than the basin production percentage from groundwater within the district.

d. Groundwater Management Plan (AB 3030 Plan)

AB 3030 is referred to as the Groundwater Management Act in California. § 10750 et seq., of the CWC (AB 3030, 1992) provides a procedure for an existing local agency to develop a groundwater management plan. This section of the CWC provides such an agency with the powers of a water replenishment district. This allows the agency to raise revenue to pay for facilities to manage the groundwater basin (extraction, recharge, conveyance, quality).

About 160 agencies have adopted AB 3030 groundwater management plans. Despite the potential for improving groundwater management, AB 3030 faces several obstacles, beginning with fact that most groundwater basins are overlain by multiple agencies.

AB 3030 allows any local public agency that provides water service to all or a portion of its service area and whose service area includes all or a portion of a groundwater basin to adopt a groundwater management program. The law contains 12 components that may be included in a groundwater management plan. Each component may play some role in evaluating or operating a groundwater basin so that groundwater can be managed to maximize the total water supply while protecting groundwater quality. Districts are authorized to adopt rules and regulations to implement and enforce the Groundwater Management Program.

In adopting the rules and regulations, the district must consider the potential impact of those rules and regulations on business activities, including agricultural operations. In addition, to the extent practicable and consistent with groundwater resource protection, the district must minimize any adverse impacts on these business activities. In contrast to most district laws that currently base voting rights on the number of registered voters, AB 3030 considers a majority protest to exist based on 50 percent of total land value.[167] Before the district may levy a water management assessment or otherwise fix and collect fees for the replenishment or extraction of groundwater the district must hold an election on the

[167] CWC § 10753.6 A majority protest shall be determined to exist if the governing board of the local agency finds that the protests filed and not withdrawn prior to the conclusion of the second hearing represent more than 50 percent of the assessed value of the land within the local agency subject to groundwater management pursuant to this part.
CWC § 10753.9. In adopting rules and regulations pursuant to Section 10753.8, the local agency shall consider the potential impact of those rules and regulations on business activities, including agricultural operations, and to the extent practicable and consistent with the protection of the groundwater resources, minimize any adverse impacts on those business activities.

proposition. A majority of votes will allow the district to proceed with the assessment and fees.

Additionally, the Central Valley Project Improvement Act's criteria for evaluating water conservation plans require all water suppliers overlying a usable groundwater basin to initiate development of a groundwater management plan pursuant to AB 3030.[168] This is the major reason that there are a substantial number of AB 3030 plans in the SJV. However, examination of several of these plans revealed few substantive components.[169]

In summary, there are two major limitations in AB 3030:

- Section 10750.4[170] states that the local agency is not required to implement a plan, even in a critically overdrafted basin.
- Section 10753.8 (c)[171] states that the local authority must show through study and examination that all other methods of alternative sources of water have proved "insufficient or infeasible" before limiting groundwater extraction.

These two provisions make it highly unlikely that AB 3030 will fulfill its stated policy goal[172] of cooperation among local agencies to manage groundwater because it eliminates any incentive for local agencies to participate. It also leaves open the door for enumerable legal challenges in the event that a rule is promulgated to limit extraction or protect groundwater quality. The text of AB 3030 is vague and places an excessive burden on the agency to

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[168] For examples of AB 3030 plans, see the Westlands Water Districts Plan and the Big Valley Groundwater Management Plan.
Westlands Water District (1996). Groundwater Management Plan: Westlands Water District.
Big Valley Groundwater Management Zone Commission (1999). Big Valley Groundwater Management Plan..
[169] Westlands Water District (1996). Groundwater Management Plan: Westlands Water District.
[170] Nothing in this part requires a local agency overlying a groundwater basin to adopt or implement a groundwater management plan or groundwater management program pursuant to this part.
[171] Nothing in this part shall be construed as authorizing the local agency to limit or suspend extractions unless the local agency has determined through study and investigation that groundwater replenishment programs or other alternative sources of water supply have proved insufficient or infeasible to lessen the demand for groundwater.
[172] CWC § 10750 (a). The Legislature finds and declares that groundwater is a valuable natural resource in California, and should be managed to ensure both its safe production and its quality. It is the intent of the Legislature to encourage local agencies to work cooperatively to manage groundwater resources within their jurisdictions.

essentially examine and prove that every other possible way of importing surface water and replenishing supply is not feasible. The cost of such studies alone would perhaps limit the ability of the agency to promulgate rules that restrict extraction.

e. City and County Ordinances

California courts have upheld the right of cities and counties to regulate groundwater under their police powers. In Baldwin v. Tehama County (1994),[173] the Court of Appeal rejected arguments that the ordinance was preempted by state law. The court reasoned that state law does not occupy the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage groundwater. Butte, Glenn, Imperial, Inyo, Kern, Lake, Napa, San Diego, San Joaquin, Shasta, Ventura, and Yolo Counties have adopted ordinances.

Despite the potential of county ordinances to serve as a basis for comprehensive groundwater management, the impact has been very limited to date. County ordinances have largely taken the form of protections against groundwater export from the county. The best example is the Groundwater Management Ordinance of Inyo County, entitled, "Regulation Of Water Transfers Undertaken Pursuant To Water Code § 1810, Sales Of Surface Water Or Groundwater To The City Of Los Angeles, And The Transfer Or Transport Of Water From Groundwater Basins Located In Whole Or In Part Within The Boundaries Of Inyo County." [174] This was largely a move to protect against the export of

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[173] *Peter Baldwin v. County of Tehama* (1994). 31 Cal. App. 4th 166.

[174] 18.77.005 Purpose and Intent.
It is the purpose and intent of this chapter to establish an effective county policy that will assure that the overall economy and the environment of Inyo County are protected from the impacts of: (1) a water transfer from the unincorporated area of Inyo County undertaken pursuant to Water Code Section 1810 et seq.; (2) a sale to the City of Los Angeles, or an acquisition by the City of Los Angeles by means other than a sale, of surface water or groundwater extracted or diverted from within Inyo County; (3) a transfer or transport of groundwater extracted from a groundwater basin located in whole or in part within the boundaries of Inyo County, for use in an area outside of the groundwater basin; and (4) a transfer or transport of groundwater extracted from

water to Los Angeles. Below is a listing of the counties that have adopted groundwater management ordinances (Figure 17).

Figure 17: Groundwater Management County Ordinances[175]	
Butte County (Measure G)[176]	Glenn County[177]
Imperial County	Inyo County
Kern County (Emergency Ordinance)	Lake County
Napa County	San Diego County
San Joaquin County	Shasta County
Tehama County	Yolo County

C. Existing Limitations in California Groundwater Law

The limitations inherent in groundwater management in California are much the same as those discussed more than 20 years ago in the Report of the Governor's Commission to Review Water Rights Law.[178] These limitations fall into the several categories of monitoring and informational uncertainty, quantification of groundwater rights, planning, coordination, and jurisdiction.[179]

At the most fundamental level, the efficient management of groundwater in California requires adequate and accurate information about the quantity and quality of the resource. A monitoring program must be in place to record changes in the resource through time to allow intervention in the case of degradation. Monitoring can be accomplished through both state and local efforts, but there is a need to keep continuous records for strategically placed wells throughout the state. DWR has consistently been insufficiently

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within Inyo County from a groundwater basin partially located within Inyo County, for use in an area within the same basin, but outside the boundaries of Inyo County.

[175] Department of Water Resources and C. J. Hauge (1999). Groundwater management in California: a report to the Legislature pursuant to Senate Bill 1245 (1997). Sacramento, CA: State of California.

[176] Butte County is an example of a more active approach to groundwater management.

[177] Glenn County has established Basin Management Objectives under the Act.

[178] Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.

[179] Jaquette, D. L., et al. (1978). Efficient water use in California : groundwater use and management. Santa Monica, CA: Rand Corporation.

Lipson, A. J., et al. (1978). Efficient water use in California : the evolution of groundwater management in Southern California. Santa Monica, CA.: Rand Corporation.

funded to perform its duties under the CWC.[180] DWR is charged with significant responsibility, yet staffing of groundwater-related positions in DWR is at approximately 2 percent of the total employment. Another approach could rely more extensively on the use of local monitoring with some state level coordination. This approach has also not been implemented. Local government, water districts, and individual groundwater users are not required or encouraged to submit data to DWR for record keeping.[181]

The extent of DWR investigation of groundwater is generally limited to the delineation of basins.[182] Groundwater also receives limited attention in the California Water Plan.[183] This degree of limited study of groundwater seems counter-indicative of the level of responsibility placed on DWR. DWR can surely not fulfill its duties without basic information about the state of groundwater. Additionally, well log data are not to be disclosed to the public, an anomaly that sets California apart from most states.[184] Well log information is critical to understanding stresses on an aquifer, such as the number and capacity of wells, along with the screened interval of the well. Given the economic resources of the state and the degree of reliance on groundwater, DWR should be authorized and funded to fulfill its statutory duties under the CWC.

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[180] 229. The department, either independently or in cooperation with any person or any county, state, federal, or other agency, to the extent that funds are allocated therefor, shall investigate conditions of the quality of all waters within the state, including saline waters, coastal and inland, as related to all sources of pollution of whatever nature. The department may recommend any steps which might be taken to improve or protect the quality of such waters. The department shall coordinate its investigations fully with the board.

[181] State Water Resources Control Board and State of California (2001). Proposal for a Comprehensive Ambient Surface Water Quality Monitoring Program. Sacramento: State of California.

[182] Department of Water Resources (1975). Bulletin 118: California's ground water. Sacramento: State of California.

Department of Water Resources (1980). Bulletin 118-80: Ground Water Basins in California: 118-80: State of California.

[183] Department of Water Resources (1998). Bulletin 160-98: California Water Plan Update. Sacramento: State of California.

[184] CWC § 13752. Reports made in accordance with paragraph (1) of subdivision (b) of Section 13751 shall not be made available for inspection by the public, but shall be made available to governmental agencies for use in making studies, or to any person who obtains a written authorization from the owner of the well.

In addition to groundwater monitoring, the State of California has not established a program to quantify groundwater rights or the level of extraction. Only in the limited situations where groundwater management districts exist or in the case of adjudication will groundwater rights be quantified. While the SWRCB is careful in the accounting of surface water supplies, the interconnection with unquantified groundwater resources may hinder management. Despite the availability of technologies to account for groundwater extraction and the fact that most groundwater users know the extent of extraction, the SWRCB and DWR have no system for directly calculating groundwater extraction. The current technique for indirectly estimating groundwater extraction in agricultural areas relies on comparing surface water deliveries to the evapotranspirational needs, plus corrections for weather, leaching requirements, etc. In many instances, groundwater extraction has been shown to affect surface water rights in many legal battles.[185] Despite the statutory authority of DWR to monitor groundwater[186] and the SWRCB's powers to prevent waste[187] and protect groundwater quality through statutory adjudication,[188] the majority of groundwater management has been carried out through the time consuming and costly process of court-based adjudications. The SWRCB and DWR could more fully utilize existing authority to improve groundwater management in California.

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[185] *City of Barstow v. Mojave Water Agency* (2000). 23 Cal. 4th 1224.
Martha H. Wright v. Goleta Water District (1986). 174 Cal. App. 3d 74; 1985 Cal. App. LEXIS 2725; 219 Cal. Rptr. 740.

[186] CWC § 231. The department, either independently or in cooperation with any person or any county, state, federal or other agency, shall investigate and survey conditions of damage to quality of underground waters, which conditions are or may be caused by improperly constructed, abandoned or defective wells through the interconnection of strata or the introduction of surface waters into underground waters. The department shall report to the appropriate California regional water quality control board its recommendations for minimum standards of well construction in any particular locality in which it deems regulation necessary to protection of quality of underground water, and shall report to the Legislature from time to time, its recommendations for proper sealing of abandoned wells.

[187] CWC § 275.

[188] CWC § 2100.

Planning has long been an important part of governmental institutions and is a basic tenet of the California Water Plan:

> CWC § 10005. (a) It is hereby declared that the people of the State have a primary interest in the orderly and coordinated control, protection, conservation, development, and utilization of the water resources of the State by all individuals and entities and that it is the policy of the State that The California Water Plan, with any necessary amendments, supplements, and additions to the plan, is accepted as the master plan which guides the orderly and coordinated control, protection, conservation, development, management and efficient utilization of the water resources of the State.

"Coordinated control and protection" are terms that would seemingly apply to addressing overdraft as present in many regions of California, a phenomenon that statewide equals approximately 2.4 cubic kilometers (2 MAF) per year. However, sections of the Water Plan addressing the TLHR did not propose strategies for reducing groundwater overdraft. Effective planning needs to be comprised of a long-term policy and specific steps to implement the policy. The planning process also has no program for reducing pesticide and nutrient contamination in groundwater.

The lack of consideration given to groundwater in the development of large surface water diversion and allocation projects has led to conflicting policies in the case of non-point source pollution control. The SWRCB is responsible for the implementation of programs to control nonpoint source pollution under the Federal Water Pollution Control Act (Clean Water Act as amended).[189] The Clean Water Act requires the SWRCB to set Total Maximum Daily Loads (TMDLs) on contaminants that pose a threat to "waters of the United States," generally defined as most rivers and lakes and exclusive of small tributaries. The San Joaquin River and several other navigable waters in the SJV have been designated as impaired.[190] However, plans for protecting surface water quality from nonpoint contamination, such as

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[189] Title 33, Chapter 26, Subchapter III, Section 1329, Nonpoint source management programs. See also CWC § 13369.

[190] State Water Resources Control Board (1999). California 303(d) List and TMDL Priority Schedule 1998. Sacramento: State of California.

salinity, boron, selenium, and pesticides, has often resulted in strategies that lead to greater accumulation in groundwater.[191]

The proposed salinity and boron TMDL illustrates the complexity of controlling surface water quality in the absence of an inclusive groundwater management program:

> Groundwater accounted for approximately 89,000 acre-feet (AF) and 192,000 tons of salt per year discharged to the Lower San Joaquin River, assuming an average accretion of 1,478 AF per mile per year and salt loading value of 3,203 tons per mile per year over the sixty-mile reach of the Lower San Joaquin River between Lander Avenue and Vernalis. The 12 miles of Mud Slough and 28 miles of Salt Sloughs account for an additional 40 miles of source area. Assuming similar accretion rates and water quality, the groundwater contribution from these sloughs adds 59,000 AF and 128,000 tons of salt per year. This suggests that groundwater accretions to the Lower San Joaquin River are approximately 148,000 AF per year, representing four percent of the mean annual discharge. These accretions add 320,000 tons of salt per year or 30 percent of the mean annual salt load in the Lower San Joaquin River at Vernalis. This estimate does not account for the groundwater salt load component of the discharges from the east side Sierra Nevada tributaries of the Lower San Joaquin River. This groundwater analysis suggests that the groundwater salt loads from the Sierra Nevada tributaries will be relatively low due to the higher quality of east side groundwater accretions.[192]

Despite the fact that groundwater is a major source of San Joaquin River salinity, most efforts have encouraged "on farm" management practices to control salt in runoff.[193] The lack of integration in the protection of groundwater and surface water quality has hindered resolution of problems associated with nonpoint source pollution, such as salts.

Planning goals and objectives are also often absent from local efforts to manage groundwater. Currently, management districts do not need to set protective goals, e.g. groundwater mining (overdraft) is permitted. User-oriented and controlled management districts are only concerned with their short term needs, often in the form of economic

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[191] State Water Resources Control Board, et al. (2000). Nonpoint Source Program Strategy and Implementation Plan, 1998-2013 (PROSIP): State of California.

[192] Regional Water Quality Control Board-Central Valley Region and California Environmental Protection Agency (2002). Total Maximum Daily Load for Salinity and Boron in the Lower San Joaquin River. Sacramento: State of California.

[193] San Joaquin Valley Drainage Implementation Program and University of California. Salinity/Drainage Task Force (2000). Final report : evaluation of the 1990 drainage management plan for the westside San Joaquin Valley, California.

gain.[194] Long-term resource protection is not often a goal. Long-term resource protection is a responsibility of the state. The lack of substantive requirements on these districts might result in adverse impacts to areas beyond their jurisdictional boundaries and to the general welfare of the state.

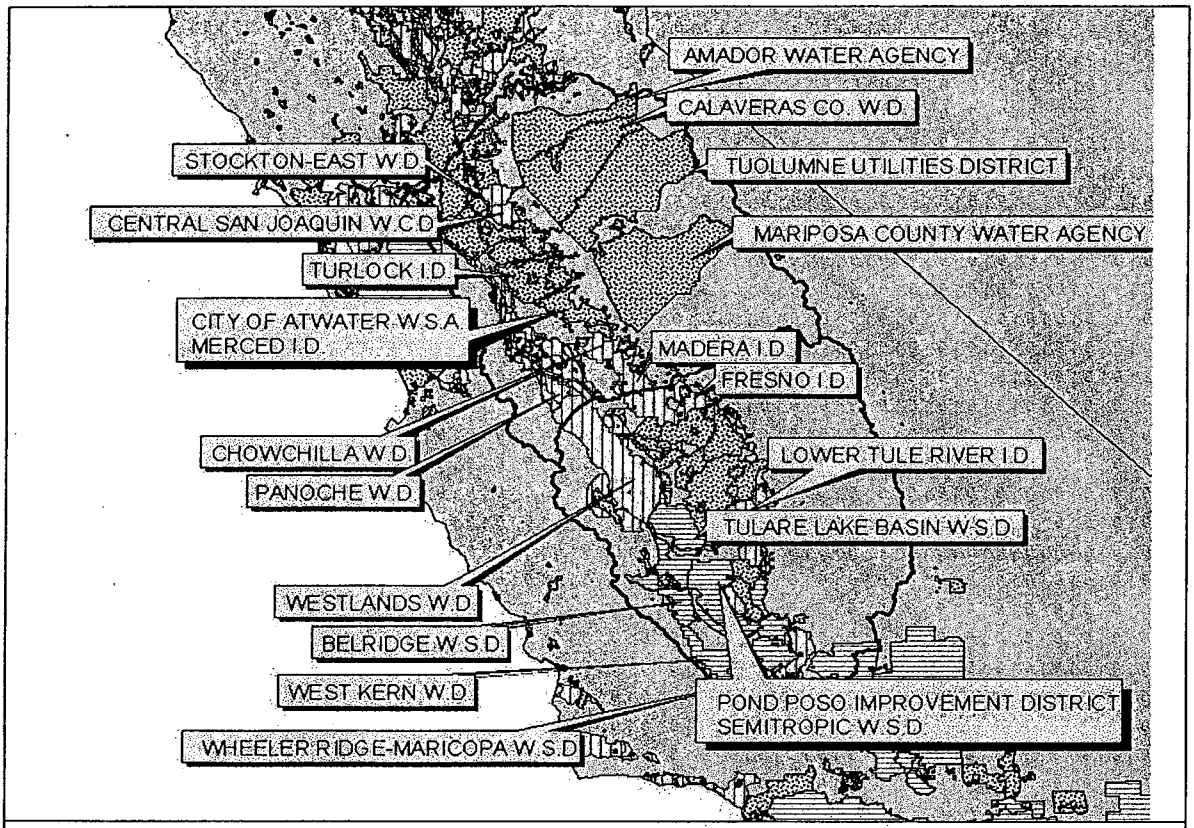

Figure 18: Major Water Districts in the San Joaquin Valley

The lack of appropriate groundwater management might also be well explained by the nature of the water districts, the unit of management and jurisdiction.[195] The complexity

[194] For an illustrative discussion of the economic and sociological aspects of the common pool resource of groundwater, see Thompson, B. H. (2000). "Tragically Difficult: The Obstacles to Governing the Commons." Environmental Law 30 Envtl. L. 241.

[195] Goodall, M. (1991). Water in California agriculture. Water in California Agriculture: Technology, Politics, and People, Sacramento. Goodall identified three trends in the San Joaquin Valley: (1) an increase in the concentration in land ownership in the San Joaquin Valley; (2) the expansion of irrigable acreage in the southern and western Valley and an increase in water districts with property-weighted electoral systems; and (3) the convergence of the major public and private water organizations in the State. He further concluded that water development fostered a new political economy in California. The weighting of voting systems by property created new institutional arrangements in which water district priorities are less likely to be influenced by the preferences of resident registered voters. This had the effect of diminishing the distinction between political and economic

and diversity of water districts, their overlapping duties and physical boundaries, has been the key obstacle for the success of local management. For local management to succeed there must be a common interest and a common area. These commons must be empowered statutorily to act collectively under democratic rules of election and decision-making. However, these traits are absent from the 157 district acts the California State Legislature has authored, commencing in the 1880s.[196] In many cases, districts do not overlie groundwater basins (see Figure 18).

Further problems rest with the limited authority of the districts and other jurisdictional authorities.[197] AB 3030 permits very limited enforcement in the form of a groundwater management plan. Individual parties can opt out without recourse. The lack of authority limits the motivation to author and submit to a groundwater plan.

The multitude of water districts and their functions has also hampered the ability of the SWRCB to establish TMDLs and assign responsibility. Without clear jurisdictional boundaries, responsibility for issues such as nonpoint source contamination is difficult to assign.

The most important consequence of California's current groundwater allocation and management regime is uncertainty. Efficient water use is premised on the need for a reliable supply of water for domestic drinking water supplies, agricultural crops, and environmental purposes. The court in the case In re Determination of Rights to Waters of Long Valley

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power and between public and private considerations of welfare. Goodall states, "both environmental degradation and social inequity have come to be described as 'development.'"

[196] Department of Water Resources (1994). Bulletin 155: General Comparison of Water District Acts. Sacramento: State of California.

[197] Department of Water Resources (1994). Bulletin 155: General Comparison of Water District Acts. Sacramento: State of California.

Creek Stream System extensively reviewed the problems with uncertainty associated with unexercised riparian rights.[198]

> Uncertainty concerning the rights of water users has pernicious effects. Initially, it inhibits long range planning and investment for the development and use of waters in a stream system.
>
> Uncertainty also fosters recurrent, costly and piecemeal litigation. In the present case, for example, there has been incessant litigation between the claimants to the waters of the stream system since about 1883. And, as the Board engineer observed, the inconclusive fragmentary definition of water rights resulting from that litigation was 'the prime reason for the proposed adjudication.' The principal cause of this untoward effect appears to be that a private suit for determining title to water binds only those who are parties to the suit; such suits are inadequate, however, because shortages in supply or new appropriations or riparian uses have the potential for bringing all water users on the stream in conflict.

The same consequences are present for groundwater, only the resource is much more difficult to allocate without a quantified permit system or data on historical levels of extraction. The ultimate goal of California groundwater policy must be to address this uncertainty for the destructive effects it has upon all water uses. Uncertainty in the year-to-year allocation of the resource and long-term resource quality are the two major challenges that confront California's groundwater policy.

Chapter IV. A Framework for Public Interest Regulation of Groundwater in the Federal System

Federal and state governments derive much of their authority to control water from the United States Constitution and common law. These powers have typically been applied to navigation, fisheries, commerce, nuisance, and actions to promote the general welfare of the United States in surface waters. Although these categories pertain most directly to surface water, the more general statement regarding the uses of private property that affect

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[198] *In re Determination of Rights to Waters of Long Valley Creek Stream System* (1979). 25 Cal.3d 339.
More generally, see also Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.

public interests, shown below from the case of Munn v. Illinois, is instructive to our discussion of groundwater:

> "This brings us to inquire as to the principles upon which this power of regulation rests, in order that we may determine what is within and what without its operative effect. Looking, then, to the common law, from whence came the fight which the Constitution protects, we find that when private property is "affected with a public interest, it ceases to be juris privati only." This was said by Lord Chief Justice Hale more than two hundred years ago, in his treatise De Portibus Marls, 1 Harg. I. Tr., 78, and has been accepted without objection as an essential element in the law of property ever since. Property does become clothed with a public interest when used in a manner to make it of public consequence, and affect the community at large. When, therefore, one devotes his property to a use in which the public has an interest, he, in effect, grants to the public an interest in that use, and must submit to be controlled by the public for the common good, to the extent of the interest he has thus created. He may withdraw his grant by discontinuing the use; but, so long as he maintains the use, he must submit to the control...."[199]

This observation, made by the United States Supreme Court more than 100 years ago, is important because it illustrates why groundwater must be considered an interconnected resource. This is perhaps more important with groundwater than with other resources given the economic incentives to mine the resource and the difficulty with management on the local scale. These and other factors make a strong argument for a clear role of public agencies in groundwater management. This chapter explores several aspects of groundwater in the larger scheme of governmental water management. These aspects include: (1) the similarity between the reasoning behind governmental involvement in surface water management to groundwater management and (2) the conflict that arises when surface water, one aspect of an interrelated resource, is managed quite differently from another aspect, groundwater. This chapter discusses how groundwater can fit into a broader scheme of water management and how public regulation is evolving in a federal system that distributes groundwater management responsibilities among various agencies of local, state, and federal governments.

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[199] *Munn v. Illinois* (1877). 94 U. S. 113.

In the early 1800s, governmental powers were commonly applied to the protection of in-stream flows for navigational purposes and fisheries. However, these powers were redefined and expanded in several cases throughout the 1800s, most notably in the landmark case of Commonwealth v. Alger (1851),[200] which developed the notion of "positive governmental authority." Broadly, this authority allows the government to control uses of water that might typically be described as nuisances to protect public rights. In so far as these controls on private undertakings protect existing public rights, they do not constitute Fifth Amendment takings .

It is this concept of public rights or public interest that is central to understanding governmental control of groundwater. As scientific knowledge of the interconnectedness of surface water and groundwater systems has advanced, it has become clearer that groundwater quality and quantity has a significant effect on surface water.[201] Applying a more general doctrine of public interest to groundwater control will provide a more adequate approach to understanding groundwater in the federal system.

This section reviews a few important cases in the fields of navigation, commerce, and nuisance with respect to water in the federal system. In conclusion, it is shown that the logic of United States Supreme Court in Commonwealth v. Alger[202] and, more recently, in

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[200] *Commonwealth v. Cyrus Alger* (1851). 61 Mass. 53; 1851 Mass. LEXIS 7; 7 Cush. 53.

[201] In the early 1900s, when groundwater law took much of its current form in California, the state legislature and the courts were not privy to the interconnectedness of groundwater to the surface water systems. Nor did the powerful turbine pumps exist that could extract large volumes of water. These scientific or technological considerations have hampered the optimal management of groundwater, for the laws that we enforce did not contemplate these issues. Developing a public rights doctrine that contemplates changes in knowledge into groundwater law will help to alleviate this problem.

[202] *Commonwealth v. Cyrus Alger* (1851). 61 Mass. 53; 1851 Mass. LEXIS 7; 7 Cush. 53.

Keystone Bituminous Coal Association v. DeBenedictis[203] is instructive for defining the role of state government in groundwater management and gaps in the current system.

A. The Federal Role in the Control of Water

Upon the ordination of the United States Constitution and preceded by the adoption of the common law of England, the United States began a foundation of law that has shaped the allocation and protection of surface and ground water. The United States Constitution outlines the boundaries of the power of the United States government, stating, albeit generally, where and under what circumstances water will be controlled by the federal government. One such interpretation of the federal role in water resources reads:[204]

> What is the basic responsibility of the Federal Government for conservation and development of water resources and power? To the extent that these activities are essential to provide for the national defense, to preserve the national domain or to regulate interstate and foreign commerce, the Federal responsibility is basic.

The Constitution further grants residual authority to the states, where such authority is not held exclusively by the people. Further, the common law of England, in addition to providing us with riparian rights, contributed the public trust and nuisance doctrines to the system. These doctrines prescribe obligations to governments vested with the protection of certain natural resources. In concert, these laws outline the authority of the state and federal government to exercise regulatory control over groundwater allocation to best serve the public interest.[205]

In summary, there are three major areas in which federal governmental authority is broadly recognized to pertain to water:

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[203] *Keystone Bituminous Coal Assn. v. DeBenedictis* (1987). 480 U.S. 470; 107 S. Ct. 1232; 1987 U.S. LEXIS 2880; 94 L. Ed. 2d 472; 55 U.S.L.W. 4326; 25 ERC (BNA) 1649; 93 Oil & Gas Rep. 300.

[204] Moreell, B., et al. (1956). Our nation's water resources, policies and politics : lectures given at the University of Chicago, April and May 1956. Chicago: Law School University of Chicago.

[205] Blomquist, W. A. (1991). Coordinating water resources in the federal system: the groundwater-surface water connection. Washington, D.C.: U.S. Advisory Commission on Intergovernmental Relations.

- those issues pertaining to the obstruction of navigation on "waters of the United States," and situations involving interstate commerce,
- in areas where the government pursues projects or other activities to promote the "general welfare" of the United States, and
- issues of nuisance and police power.

The reach of the federal government extends to water most tangibly through Article I, § 8, Clause 3 of the United States Constitution,

> The Congress shall have Power . . . To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes.

By virtue of the navigability of most rivers and lakes and the importance of navigation to commerce, Congress has the authority to regulate navigable waters. Under this authority, the Navigable Rivers and Harbors Act and Federal Water Pollution Control Act have become the law of the United States. This authority has been applied to diverse areas, such as erosion and the interstate transport of groundwater.

The first major case involving the United States Supreme Court in an analysis of the constitutional issue of federal and state power over interstate commerce came in 1824 in the case of Gibbons v. Ogden.[206] The problem arose when the State of New York granted exclusive navigation rights to all water within the jurisdiction of the State of New York to R. R. Livingston and R. Fulton. Livingston and Fulton assigned Ogden the right to operate between the ports of New York City and New Jersey.

A second party, Gibbons, owned two steamships running between New York and Elizabethtown, which were licensed under an act of Congress. Ogden, in an attempt to enforce his sole right of navigation obtained under state law, gained an injunction against Gibbons, who appealed to the United States Supreme Court. The question Gibbons asked

[206] *Gibbons v. Ogden* (1824). 22 U.S. 1; 6 L. Ed. 23; 1824 U.S. LEXIS 370; 9 Wheat. 1.

the Supreme Court to address was whether or not the grant of exclusive navigation rights to Ogden was repugnant to the United States Constitution on the grounds that the Constitution authorizes Congress to regulate commerce.

In rendering his opinion on the subject, Chief Justice Marshall contemplated the nature of state sovereignty in ratifying the United States Constitution. With the ratification of the Constitution, the states authorized Congress the right "To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes." Commerce is understood as intercourse, and Marshall found the Constitution comprehended navigation with regard to commerce. In conclusion, the Court found this power over commerce as conferred by the Constitution to Congress to be the power to regulate and "prescribe the rule by which commerce is to be governed."

This case of Gibbons v. Ogden is significant to our analysis for its extension of federal government authority into navigable waters of each state. It provided a foundation upon which the federal government would later justify many aspects of federal intervention in water resources regulation and protection, such as the Navigable Rivers and Harbors and Federal Water Pollution Control and Prevention Acts.[207]

A great extension of Congressional control over navigation occurred by the decision of United States V. Rio Grande Dam and Irrigation Company, (1899).[208] A problem arose when the appropriation of water from the Rio Grande River began to diminish flows substantially to injure navigation. Although the allocation of water within state boundaries has long been viewed to be a delegated right resting with the state government, excessive

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[207] A similar issue involving navigation came before the California Supreme Court in *James Eldridge v. John Cowell* (1854). 4 Cal. 80..

[208] *United States v. Rio Grande Dam and Irrigation Company* (1899). 174 U.S. 690; 19 S. Ct. 770; 43 L. Ed. 1136; 1899 U.S. LEXIS 1528.

allocation of such waters impaired the navigability of waters under the purview of Congress and the federal government. The United States Supreme Court found that although Congress recognized the appropriation of water as a state issue, "it is not to be inferred that Congress thereby meant to confer on any state the right to appropriate all the waters of the tributary streams which unite into a navigable watercourse, and so destroy the navigability of that watercourse in derogation of the interests of all the people of the United States." The actions that interfere with navigability of water interfere with interstate commerce and are thereby void.

In 1899, Congress also passed the Navigable Rivers and Harbors Act, codifying procedures and regulations on issues pertaining to the obstruction of navigable waters. § 403 of the Act as codified prohibits the creation of any obstructions, not authorized by Congress, to the "navigable capacity" of all waters of the United States. All such plans must be authorized by the Secretary of the Army. This Act provided clarity to the role of the federal government in navigation by providing specific definitions and establishing a permit system for actions potentially injurious to navigation.

The federal government demonstrated another sphere of influence over water through the general welfare clause in the case of Ivanhoe Irrigation District v. McCracken,[209] which came before the Supreme Court of the United States in 1958. This case involved two federal reclamation projects, the Central Valley and the Santa Barbara County Projects. In order to implement these projects, the United States signed contracts with two California irrigation districts and the Santa Barbara County Water Agency. These contracts contained the provisions that:

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[209] *Ivanhoe Irrigation District v. McCracken* (1958). 357 U.S. 275; 78 S. Ct. 1174; 2 L. Ed. 2d 1313; 1958 U.S. LEXIS 1774.

(1) project water cannot be delivered to land holdings in a single ownership over 0.65 square kilometers (160 acres);

(2) the United States would furnish water to the districts and the agency for a period of 40 years; and

(3) repayment of the project to the government would be spread out over 40 years, without interest.

These contracts were attacked on several points and found unconstitutional in the Supreme Court of California. On appeal to the United States Supreme Court, the judgments of the California Supreme Court were reversed. The key issues before the United States Supreme Court were:

(1) whether the validity of the contracts was governed by federal or by state law and

(2) whether the contracts, and the federal statutes requiring the provisions listed above, were valid under the due process and equal protection clauses of the Fifth and Fourteenth Amendments.

After analyzing federal policy as to federal reclamation projects, the court found that the contracts were governed by federal law and legitimate. In doing so, the court affirmed a power of Congress that has helped to shape the management of water in California.

The role of Congress and the federal government in navigable waters of the United States entered a new context with the passage of the Federal Water Pollution Control Act of 1948 (Clean Water Act, 1973). The act (as currently amended) requires permits for discharges of pollutants to "waters of the United States," prohibits most types of injection wells for pollutants, and has recently required controls on land uses and nonpoint source pollution that impair "waters of the United States." The full reach of the Clean Water Act into federal regulation of groundwater has not been demonstrated, although it is the topic of

several recent articles.[210] The future role of the Clean Water Act might be quite large in protecting groundwater quality, an area largely reserved for the states until recent years.[211] The attempt to separate groundwater from surface water and quality from quantity has made distributing authority between the federal government and the states a complex task and stirred conflict.

The federal role in regulating groundwater was tangibly addressed in Sporhase v. Nebraska.[212] The decision ultimately found that a Nebraska statute forbidding withdrawal of ground water to foreign state that denies such privileges to Nebraska violates the commerce clause.[213]

Landowners held contiguous tracts of land in Nebraska and Colorado on which a well physically located in Nebraska extracted groundwater for irrigation of both tracts on both sides of the border. These landowners failed to apply for a permit as required by

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[210] See also Malone, L. A. (1990). "The Necessary Interrelationship Between Land Use and Preservation of Groundwater Resources." UCLA Journal of Environmental Law & Policy 9 UCLA J. Envtl. L. & Pol'y 1.
Alder, R. W. (1995). "Addressing Barriers to Watershed Protection." Environmental Law 25 Envtl. L. 973.
Flatt, V. B. (1997). "A Dirty River Runs Through It (The Failure of Enforcement in the Clean Water Act)." Boston College Environmental Affairs Law Review 25 B.C. Envtl. Aff. L. Rev. 1.
Vance, B. R. (1994). "Total Aquifer Management: A New Approach to Groundwater Protection." University of San Francisco Law Review 30 U.S.F.L. Rev. 803.
Quatrochi, P. M. (1996). "Groundwater Jurisdiction Under the Clean Water Act: The Tributary Groundwater Dilemma." Boston College Environmental Affairs Law Review 23 B.C. Envtl. Aff. L. Rev. 603.
Althaus, H. F., et al. (1978). Public trust rights. Washington: U.S. Fish and Wildlife Service. Manning, G. V. (1987). "The Extent of Groundwater Jurisdiction Under the Clean Water Act After Riverside Bayview Homes." Louisiana Law Review 47 La. L. Rev. 859.
Blomquist, W. A. (1991). Coordinating water resources in the federal system: the groundwater-surface water connection. Washington, D.C.: U.S. Advisory Commission on Intergovernmental Relations.
Blomquist, W. A. (1991). "Taking federalism underground : managing water resources." Intergovernmental perspective 17(3): 6-7, 24.

[211] Title 33, §1251(g): Authority of States over water
It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this chapter. It is the further policy of Congress that nothing in this chapter shall be construed to supersede or abrogate rights to quantities of water which have been established by any State. Federal agencies shall co-operate with State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources

[212] *Sporhase et al. v. Nebraska Ex Rel. Douglas, A. G.* (1982). 458 U.S. 941; 102 S. Ct. 3456; 1982 U.S. LEXIS 13; 73 L. Ed. 2d 1254; 50 U.S.L.W. 5115; 12 ELR 20749. 458 U.S. 941

[213] Article I, Sect. 8, Cl. 3

Nebraska law. This law required that foreign states grant reciprocal rights to withdraw and transport ground water into Nebraska in order to approve use in another state. Colorado did not allow reciprocity for the use of groundwater.

Nebraska sued to enjoin the landowners from transferring the water across the border without a permit in the District Court of Chase County, Nebraska. The court granted an injunction and rejected the defense that the statute imposed an undue burden on interstate commerce. The decision was upheld by the Supreme Court of Nebraska, holding that groundwater is not a marketable item freely transferable for value among private parties and therefore is not an article of commerce.

On appeal, the United States Supreme Court reversed and remanded. In an opinion by Stevens, it was held that:

(1) groundwater is subject to congressional regulation because it is an article of commerce,

(2) the Nebraska reciprocity provisions violated the commerce clause by frustrating interstate commerce, even though the conditions set forth in the statute for granting a permit— that withdrawal of the groundwater be reasonable and not detrimental to the public welfare— did not impermissibly burden interstate commerce, since the reciprocity provision operated as an explicit barrier to commerce between the states and where there was no evidence that the restriction is narrowly tailored to the asserted local purposes of conservation and preservation, and

(3) Congress has not granted the states permission to engage in groundwater regulation that would otherwise be impermissible, neither the fact that Congress has chosen not to create a federal law to regulate water rights involved in federal water projects nor the fact that Congress has been willing to let the states settle their differences over water rights with a mutual agreement.

The dissenting opinion, authored by Rehnquist, expressed the view that since Nebraska recognizes only a limited right to use groundwater on land owned by the appropriator, it cannot be said that commerce in ground water exists as far as Nebraska is concerned and therefore, it cannot be said that the statute either discriminates against, or burdens, interstate commerce.

This case leaves a door open for the federal government to intervene more extensively in groundwater management in the west. First, it finds that groundwater is an article of commerce, even when the commodity does not change ownership. Second, it second-guesses the desire of the State of Nebraska to protect the public welfare in favor of protecting commerce. Third, it suggests that federal control of groundwater rights in the west is a plausibility. In authoring an opinion, the court has done little to reduce the uncertainty associated with water in the west.

The federal involvement in groundwater is still not well defined. The potential of the Clean Water Act to control ambient groundwater quality through nonpoint source provisions and the unexercised power to control groundwater quantity seems to leave the states with an unclear impression of their role in controlling groundwater. In total, the federal government could utilize several existing mechanisms to manage groundwater, including: (1) Safe Drinking Water Act provisions (source water protection and assessment), (2) Clean Water Act provisions (nonpoint source controls and TMDLs), (3) Endangered Species Act provisions (controls to limit overdraft that affects listed species), and (4) issues of commerce and interstate compacts. Nonetheless, the heterogeneous nature of groundwater in the physical environment does lend itself toward local control. In examining the state's role, the distribution of authority and responsibility at various levels in the federal system is considered.

B. The State Role in the Control of Water

The role of the state government in water and groundwater is of a different character than that of the federal government. The state government is charged with more responsibility over water allocation, stemming from the many details left to the state's discretion by the United States Constitution.[214] However, the state also has more discretion in areas such as:

- navigation and fish protections,
- public trust, and
- public interest (police powers, nuisance)[215]

Although these principles have typically applied only to surface waters, an increased understanding of the groundwater-surface water connection has increased their applicability to groundwater. As the understanding of the role of groundwater in basin hydrology has improved, many courts have sought protections from groundwater overdraft, recognizing the effect of one well on other wells and streams.[216] Pumping groundwater decreases available surface flows, perhaps injuring fish species or navigation. These connections have prompted increases in the administrative role of many states to controlling the allocation of groundwater.

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[214] U.S. Constitution, Article X. The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people.
[215] Some recent cases upholding navigation and public rights include:
Alaska v. Ahtna, Inc. (1989), 891 F.2d 1401.
"To deny that this use of the river is commercial because it relates to the recreation industry is to employ too narrow a view of commercial activity."
David Zinkie (1990), 53 F.E.R.C. 61,029.
Fawn River in Indiana found navigable under Commerce Clause based solely on its potential for commercial recreation, even though no evidence was presented of any actual commercial recreational operations.
United States v. Appalachian Electric Power Co (1940)., 311 U.S. 377.
"Nor is lack of commercial traffic a bar to a conclusion of navigability where personal or private use by boats demonstrates the availability of the stream for the simpler types of commercial navigation."
[216] *Cline v. American Aggregates Corporation* (1984). 15 Ohio St. 3d 384.

However different the protections for fish and navigation may seem, they all work in the direction of protecting public rights in these areas. Many of the court rulings are based simply on common law that aimed to limit the extent a private undertaking can limit public rights or the public interest. This section will highlight these advances and proposes a broader framework for grouping governmental control over water resources as public interest regulation.

Some of the earliest cases of state government intervention in water resources concern the construction of mills in New England in the early 1800s. The construction of such mills impaired the rights of fishing and navigation, long observed as a public right at common law. One of the most important of these cases is The Inhabitants of the Towns of Stoughton, Sharon, and Canton, v. Edmund Baker and Daniel Vose, (1808).[217] The conflict arose over a mill constructed in 1633 by Israel Stoughton by a grant from the town of Dorchester. This grant was also confirmed by the colonial government and the mill was constructed at Milton Lower Mills.

In the original grant, no provision for fish passage up the Neponset River was recorded, and fishways were only installed in 1805 after the legislature appointed a committee with the power to require such structures. After requiring the installation of fishways at the cost of Israel Stoughton, a suit was brought. The court held that the right to have the fish pass up the river was a public right and that each owner of a mill dam holds it with an easement that a sufficient and reasonable passage shall be provided for the fish. The court held further that this easement could not be destroyed by the failure of the government to compel the mill holder to comply. The opinion reads,

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[217] *The Inhabitants of the Towns of Stoughton and Sharon and Canton v. Edmund Baker and Daniel Vose* (1808). 4 Mass. 522; 1808 Mass. LEXIS 139.
See Also, *Burnham v. Webster*, 5 Mass. 266; *Commonwealth v. Ruggles*, 10 Mass. 391.

> "Stoughton took a fee in the mill privilege, with a right to build a dam; but this right was under several implied limitations; one was to protect the rights of the public in the fishery, so that the dam must be so constructed that the fish should not be interrupted in their passage up the river to cast their spawn. This limitation, being for the benefit of the public, is not extinguished by any inattention or neglect in compelling the owner to comply with it."

This idea was further developed in the case of Commonwealth v. Chapin, (1827).[218] In this case two public rights were clearly stated to be preserved and maintained for general and common use. These rights are held as public although every portion of the soil over which the rivers flow is the private property of the riparian owners. These are:

(1) the right of passage with boats, rafts, and other vessels adapted to the use of such waters and
(2) the right of the public to have these rivers kept open and free for the migratory fish, such as salmon, shad and alewives, to pass from the sea, through such rivers, to the ponds and head waters, to cast their spawn.

Both of these rights are recognized as public rights in the case of Commonwealth v. Chapin.

The defendant was brought into court for constructing a dam across Connecticut River. The dam was alleged to be a nuisance at common law in three regards:

(1) as obstructing the navigability of the river,
(2) as injuring the health of local inhabitants, and
(3) as obstructing the passage of fish through the river upstream.

The jury found that the dam did not obstruct navigation nor injure public health. However, the jury did find that it obstructed the passage of migrating fish.

Although the river was not technically navigable at this place, the right to navigate with boats and other suitable vessels was a public right. This decision was reached despite the fact that the all soil under the river was owned by the riparian proprietors. Although

[218] *Commonwealth v. Enoch Chapin* (1827). 22 Mass. 199; 1827 Mass. LEXIS 66; 5 Pick. 199.

such riparian owners had a right to take fish from their shores, this right was subordinate to the public right to have the fish migrate up to the headwaters. Further, although the riparian owners possessed the entire bed of the river, they could not so use it as to obstruct the passage of fish. The court finally stated that such a public right may be declared, regulated, and enforced by the legislature by statute.

These previous cases confirmed the right of the government to protect public rights without clearly addressing whether such situations constituted Fifth Amendment takings. In other words, should these parties be compensated for having to include fishways or protect navigation?

The issue as to whether such situations raised takings concerns was brought before the court in the case of Commonwealth v. William Tewksbury, (1846). The case attempted to answer several questions, such as: Does the legislature have a constitutional authority to make such laws without providing compensation for the owners? Is such a law an appropriation to public use of land belonging to parties who own land bordering on the seashore?

The court did not believe that such an action constituted a taking, stating:

> The court are of opinion that such a law is not a taking of the property for public use, within the meaning of the constitution, but is a just and legitimate exercise of the power of the legislature to regulate and restrain such particular use of property as would be inconsistent with, or injurious to, the rights of the public. All property is acquired and held under the tacit condition that it shall not be so used as to injure the equal rights of others, or to destroy or greatly impair the public rights and interests of the community; under the maxim of the common law, sic utere tuo ut alienum non loedas.

Actions that are considered nuisances at common law can be regulated by the state without the concern of takings. The common example is of a riparian landowner who would cut away the riverbank so as to render the river too shallow for navigation.

Nevertheless, this notion of a nuisance is pertinent to many other issues, most importantly groundwater. Where the protections of a fishery and navigation do not apply, the notion of public nuisances injurious to both groundwater quality and quantity could be pursued.

In Commonwealth vs. William Tewksbury,[219] the court wrote that the legislature ought by positive enactment prohibit uses of property that would be injurious to the public. Conversely, they might not restrain a similar use of property where the public good is not injured. They also constrained their comments stating, "This is undoubtedly a high power, and is to be exercised with the strictest circumspection, and with the most sacred regard to the right of private property, and only in cases amounting to an obvious public exigency."

Commonwealth v. Alger in 1851 further defined this police power of the state to protect the public interest and combined common law traditions with new constitutional and statutory law.[220] In the case, the opinion of Justice Lemuel Shaw developed a doctrine of public nuisance that broadly states that uses of private property must not harm other private owners and also be free from harm to the public itself.

In the opinion of Justice Lemuel Shaw, the combination of nuisance concepts and property rights meant that, "like all other social and conventional rights," property rights must be "subject to such reasonable limitations in their enjoyment, as shall prevent them from being injurious, and to such reasonable restraints and regulations established by law, as the legislature, under the governing and controlling power vested in them by the constitution, may think necessary and expedient."

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[219] *Commonwealth v. William Tewksbury* (1846). 52 Mass. 55; 1846 Mass. LEXIS 17; 11 Met. 55.
[220] Scheiber, H. N. (1984). "Public Rights and the Rule of Law in American Legal History." California Law Review 71 Calif. L. Rev. 217.

This policing power to abate public nuisances was not, however, restricted to the abatement or regulation of only what the common law considered nuisances. In order to foster certainty in both property rights and the protection against public nuisances, Shaw stated that the legislature should define the bounds of naissance in a continuously evolving society. This situation is much analogous to that of reasonable use in water, where it has been clearly seen in California that court-based proceedings to determine reasonable and beneficial uses of water often yield inconsistent outcomes. Additional legislative and administrative action could bring better clarity to the process. Shaw further stated that all real property "is subject to some restraint for the general good", intending to include both traditional common law definitions of public goods (navigation) and a broader, evolutionary definition cognizant of "rights of the community."

Shaw's police power doctrine was significant in the positive concept of public rights as a way of justifying the use of the state's regulatory powers, fostering the idea that:[221]

> All property is acquired and held under the tacit condition that it shall not be so used as to injure the equal rights of others, or to destroy or greatly impair the public rights and interests of the community . . ..

Shaw's decision advanced the idea of public nuisance beyond court intervention to protect public interests. Instead he used public nuisance to justify governmental authority. The protection of the public was the logic used to justify regulation.[222] Despite its provident outcome, this concept has had little application to regulating groundwater in California. California groundwater law seems trapped within a myopic evolutionary path that has overlooked fundamental protection of the resource infrastructure in favor of creating an incentive system to over-utilize the resource in the short term.

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[221] *Commonwealth v. William Tewksbury* (1846). 52 Mass. 55; 1846 Mass. LEXIS 17; 11 Met. 55. at 57.
[222] Scheiber, H. N. (1984). "Public Rights and the Rule of Law in American Legal History." California Law Review 71 Calif. L. Rev. 217.

The ability of a legislature to protect the public through price limits was tested before the United States Supreme Court in the case of Munn v. Illinois, (1877).[223] Ira Munn et al. were grain warehousemen in Chicago, Illinois, and were sued by Illinois for transacting business without a state license in violation of a state statute that provided a maximum of charges for the storage of grain in a warehouse. Munn et al. admitted to the fact of charging above the maximum rate, but alleged that the statute requiring the license was unconstitutional for attempting to fix that maximum rate of storage, on the grounds that it violated the commerce clause of the United States Constitution.

The court disagreed and found that the General Assembly of Illinois can fix by law, regulations for the storage of grain in warehouses at Chicago and other places in the state. The opinion reads:

> "Property does become clothed with a public interest when used in a manner to make it of public consequence, and affect the community at large. When, therefore, one devotes his property to a use in which the public has an interest, he, in effect, grants to the public an interest in the use, and must submit to be controlled by the public for the common good, to the extent of the interest he has thus created. He may withdraw his grant by discontinuing the use; but so long as he maintains the use, he must submit to the control. We know that this is a power which may be abused; but that is no argument against its existence. For protection against abuses by legislatures the people must resort to the polls, not to the courts."

A more recent application of this public interest or police power doctrine has occurred in the case of Keystone Bituminous Coal Assn. et al. v. DeBenedictis, (1987).[224] Pennsylvania's Bituminous Mine Subsidence and Land Conservation Act prohibits coal mining that causes subsidence damage to pre-existing public buildings, dwellings, and other structures. The petitioners, who own substantial coal reserves under lands protected by the act, filed suit in Federal District Court seeking to enjoin the enforcement of the act. In

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[223] *Munn v. Illinois* (1877). 94 U. S. 113.

[224] *Keystone Bituminous Coal Assn. v. DeBenedictis* (1987). 480 U.S. 470; 107 S. Ct. 1232; 1987 U.S. LEXIS 2880; 94 L. Ed. 2d 472; 55 U.S.L.W. 4326; 25 ERC (BNA) 1649; 93 Oil & Gas Rep. 300.

particular the petitioners sought to eliminate the requirement that they leave coal in the ground to provide structural support. The District Court sided with the State of Pennsylvania. The Court of Appeals affirmed, holding that Pennsylvania Coal Co. v. Mahon[225] does not apply; that the Act does not affect a taking; and that the effect on private contracts given the act was warranted to protect public interests. The opinion reads:

> Unlike the statute considered in Pennsylvania Coal, the Act is intended to serve genuine, substantial, and legitimate public interests in health, the environment, and the fiscal integrity of the area by minimizing damage to surface areas. None of the indicia of a statute enacted solely for the benefit of private parties identified in Pennsylvania Coal are present here. Petitioners' argument that [Section] 6's remedies are unnecessary to satisfy the Act's public purposes because of the Commonwealth's insurance program that reimburses repair costs is not persuasive, since the public purpose is served by deterring mine operators from causing damage in the first place by making them assume financial responsibility. Thus, the Commonwealth has merely exercised its police power to prevent activities that are tantamount to public nuisances. The character of this governmental action leans heavily against finding a taking.

This case and the previous decisions shown here demonstrate the authority of the state to control natural resources for public interest. Other common law tenets, such as the public trust doctrine, have also been extensively applied in the courts of several states to protect public rights in water resources. These principles have been applied in various ways in California, as parts of the Constitution, the CWC, and case law. Each has helped defined the times and places in which the government will intervene to protect public interests in resources such as groundwater.

C. The Significance to California Groundwater

The State of California has built up a significant role in the regulation of surface water and groundwater. The most prominent declaration is found in the California Constitution, Article X, §2.,

[225] *Pennsylvania Coal Company v. Mahon et al.* (1922). 260 U.S. 393; 43 S. Ct. 158; 67 L. Ed. 322; 1922 U.S. LEXIS 2381; 28 A.L.R. 1321.

> 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 waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters 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 right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water. Riparian rights in a stream or water course attach to, but to no more than so much of the flow thereof as may be required or used consistently with this section, for the purposes for which such lands are, or may be made adaptable, in view of such reasonable and beneficial uses; provided, however, that nothing herein contained shall be construed as depriving any riparian owner of the reasonable use of water of the stream to which the owner's land is riparian under reasonable methods of diversion and use, or as depriving any appropriator of water to which the appropriator is lawfully entitled. This section shall be self-executing, and the Legislature may also enact laws in the furtherance of the policy in this section contained.

Further, Article X, §5 declares a regulatory interest in all waters of the state,

> The use of all water now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution, is hereby declared to be a public use, and subject to the regulation and control of the State, in the manner to be prescribed by law.

Several other states have embraced this public interest language in their constitutions.[226] This public interest language has often been understood to embrace the heritage of the public trust doctrine, a common law principle that protects the rights of the

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[226] Montana Const., Article IX, Sec. 3
"All Surface, underground, flood, and atmospheric waters within the boundaries of the State are the property of the State for the use of its people and are subject to appropriation for beneficial uses as provided by law."
Alaska Const., Article VIII, Sec. 3
"Wherever occurring in their natural state, fish, wildlife and waters are reserved for the people for common use."
New York State Public Land Law, Sec. 75 (7)(a)
"In making any grant, lease, permit or other conveyance, the commissioner of general services shall, upon administrative findings, and to the extent practicable, reserve such interests or attach such conditions to preserve the public interest in use of state-owned land underwater and waterways for navigation, , commerce, fishing, bathing, recreation, environmental protection and access to the navigable waters of the state, with due regard for the need of affected owners of private property to safeguard their property."
Pennsylvania Constitutional Amendment approved by referendum, 1971
Section 27. Natural resources and the public estate
"The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and aesthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."
Weber, G. S. (1994). "Forging a More Coherent Groundwater Policy in California: State and Federal Constitutional Law Challenges to Local Groundwater Export Restrictions." Santa Clara Law Review 34 Santa Clara L. Rev. 373..

public in navigable waters. Although this doctrine does share broad similarities with the intent of the constitutional language found in California, the application of the public trust doctrine is of a different nature. Efforts to link this police power to protect public interest with the public trust doctrine has led to unsuccessful efforts to apply the doctrine to contexts clearly beyond its common law history.[227]

The most successful application of the public trust doctrine to California occurred in the well-known Mono Lake case, National Audubon Society et al. v. Department of Water and Power of The City Of Los Angeles, (1983).[228] In 1940, the Division of Water Resources (predecessor to the SWRCB) had issued permits to divert water from four streams tributary to Mono Lake to the Department of Water and Power (DWP). By 1970, DWP had constructed two diversion tunnels and was taking nearly the entire supply of these streams to supply Los Angeles. As a result, the surface level in Mono Lake dropped nearly 13 meters (40 feet) and the surface area diminished by one-third by the mid-1970s. This concentrated salts in the lake, damaging the aquatic community and higher organisms, such as birds, which depend on it. National Audubon Society filed suit to enjoin the diversions under the theory that Mono Lake and its shores reside in the public trust. The Supreme Court ruled in favor of the National Audubon Society. In the opinion, Justice Broussard wrote:

> In our opinion, the core of the public trust doctrine is the State's authority as sovereign to exercise supervision and control over the navigable waters of the state and the lands underlying those waters. This authority applies to Mono Lake and bars DWP or any other party from claiming a vested right to divert waters once it becomes clear that such diversions harm the interests protected by the public trust.
>
> Approval of such a diversion without considering public trust values, however, may result in needless destruction of those values.

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[227] *Golden Feather Community Assocation et al. v. Thermalito Irrigation District et al.* (1989). 209 Cal. App. 3d 1276; 1989 Cal. App. LEXIS 392; 257 Cal. Rptr. 836.

[228] *National Audubon Society et al., P., v. The Superior Court of Alpine County, Respondent; Department of Water and Power of the City of Los Angeles et al., Real Parties in Interest,* (1983). 33 Cal.3d 419.

While the application of the public trust doctrine to navigable surface waters has done well to protect public rights in California, there have been no successful attempts to extend the doctrine to groundwater. The major obstacle to applying the public trust doctrine to groundwater is the inherent non-navigability of the resource. In this regard, the most significant defeat came in the case of Golden Feather Community Association v. Thermalito Irrigation District, (1989).[229] In this case the court was asked to consider whether members of the public may assert the public trust doctrine in order to compel authorized appropriators of water from a non-navigable stream to continue their diversion of water but forego their use of the diverted water in order to maintain an artificial reservoir for the recreational use of the public. The court held that the public trust doctrine does not apply in these circumstances, largely citing the non-navigability of the waterway.

However, groundwater extraction that affects public trust values of navigable waters could potentially link the doctrine to groundwater. A similar connection could potentially exist through California Fish and Game Code provisions protecting migrating salmon. In this regard, groundwater extraction might be regulated to protect rivers. Although public trust values would likely be limited to tributary groundwater, endangered species protections through the Endangered Species Act or California Fish and Game Code could potentially be brought up as an argument to limit the extraction of percolating groundwater under the theory that critical habitat might be effected.

Indications of the SWRCB's authority to promote reasonable and beneficial use provisions of the California Constitution and CWC §275 are also present in the following

[229] 209 Cal. App. 3d 1276

cases:[230] Environmental Defense Fund v. East Bay Municipal Utility District (1977), Imperial Irrigation District v. State Water Resources Control Board (1990), and United States of America v. State Water Resources Control Board (1986). One author writes (footnotes omitted):[231]

> Though the Supreme Court has not yet expressly addressed the question whether Water Code § 275 provides an independent source of jurisdiction over pumpers of percolating groundwater, the holding of the IID[232]case, along with the language of EDF I[233], and the Racanelli decision[234], are significant authority in favor of the claim that the Board can assert jurisdiction over percolating groundwater pumping to adjudicate and remedy claims that come within the scope of waste and unreasonable use covered by Water Code § 275. Such jurisdiction could be a powerful tool to deal with pumping that impairs instream flows needed to protect fish and riparian values, one of the major issues underlying complaints urging the Board to take a broadened view of its jurisdiction under Water Code §1200.

Although the precedent establishing limited involvement in groundwater protection under the public trust doctrine in California case law will likely not be altered in the near future, other states have taken a different approach to the public trust doctrine and applied it to groundwater. The most recent and important of these cases is the case In the Matter of the Water Use Permit Applications, Petitions for Interim Instream Flow Standard Amendments, and Petitions for Water Reservations for the Waihole Ditch Combined

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230 *Environmental Defense Fund v. East Bay Municipal Utility District* (1977). 20 Cal. 3d 327; 572 P.2d 1128; 1977 Cal. LEXIS 199; 142 Cal. Rptr. 904; 12 ERC (BNA) 1134; 8 ELR 20105.
Imperial Irrigation District v. State Water Resources Control Board (1990). 225 Cal. App. 3d 548; 1990 Cal. App. LEXIS 1211; 275 Cal. Rptr. 250; 90 Cal. Daily Op. Service 8504.
United States of America v. State Water Resources Control Board (1986). 182 Cal.App.3d 82.
231 Sax, J. L. (2002). Review Of The Laws Establishing The SWRCB's Permitting Authority Over Appropriations Of Groundwater Classified As Subterranean Streams And The SWRCB's Implementation Of Those Laws. Sacramento: State Water Resources Control Board.
232 *Imperial Irrigation District v. State Water Resources Control Board* (1990). 225 Cal. App. 3d 548; 1990 Cal. App. LEXIS 1211; 275 Cal. Rptr. 250; 90 Cal. Daily Op. Service 8504.
233 *Environmental Defense Fund v. East Bay Municipal Utility District* (1977). 20 Cal. 3d 327; 572 P.2d 1128; 1977 Cal. LEXIS 199; 142 Cal. Rptr. 904; 12 ERC (BNA) 1134; 8 ELR 20105.
234 *United States of America v. State Water Resources Control Board* (1986). 182 Cal.App.3d 82.

Contested Case Hearing, (2000).[235] The Supreme Court of Hawaii held the public trust doctrine did apply to groundwater, stating,

> "In sum, given the vital importance of all waters to the public welfare, we decline to carve out a ground water exception to the water resources trust. Based on the plain language of our constitution and a reasoned modern view of the sovereign reservation, we confirm that the public trust doctrine applies to all water resources, unlimited by any surface-ground distinction."

However, even if the public trust doctrine should not apply to groundwater, the state is still left with a significant authority and reason to control water for public benefit. The true nature of the State of California's ownership interest in groundwater was examined in State of California v. The Superior Court of Riverside County, (2000). In this case, insurance companies claimed that they were not responsible for groundwater remediation under the exclusion that if the property is not owned by the insured, then it is not their responsibility to reimburse.[236] In interpreting the state's ownership interest in groundwater, the court stated,

> "In our view, Water Code section 102 is an example of what the United States Supreme Court has called a 'fiction expressive in legal shorthand of the importance to its people that a State have power to preserve and regulate the exploitation of an important resource.' (Sporhase v. Nebraska ex rel. Douglas (1982) 458 U.S. 941). This power, of course, derives from the police power conferred by the United States Constitution. Water Code section 102 thus expresses the preeminent right of the people of the state to make water policy and control water usage; it may perhaps also have been intended as a preemptive strike against any private effort to claim "ownership" in a proprietary sense. But the State's power under the Water Code is the power to control and regulate use; such a power is distinct from the concept of "ownership" as used in the Civil Code and in common usage. The Code Commissioner's note to section 102 comments that pursuant to the Constitutional provision above quoted, "the State exercises governmental, rather than strictly proprietary, control over the water resources of the State."

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[235] *In the Matter of the Water Use Permit Applications Petitions for Interim Instream Flow Standard Amendments and Petitions for Water Reservations for the Waihole Ditch Combined Contested Case Hearing* (2000). 94 Haw. 97; 9 P.3d 409; 2000 Haw. LEXIS 255.

[236] *The State of California v. Underwriters at Lloyd's of London* (2000). 78 Cal. App. 4th 1019.

D. Summary

The proceeding sections regarding the approaches to governmental control over aspects of water allocation and protection demonstrate very fundamentally that water management is a responsibility distributed between state and federal governments. An evolution has taken place that began with very broad assertions of governmental authority to protect against public nuisances in the cases of Munn v. Illinois and Commonwealth v. Alger.[237] The evolution has continued towards recognition of the governmental role in groundwater as stated in the case of The State of California v. Underwriters at Lloyd's of London and in portions of the California Constitution and CWC. Further, these powers of government need to be viewed as a reasonable exercise of positive governmental authority, i.e. powers exercised under the police powers doctrine or public trust doctrine, thereby diminishing Fifth Amendment takings claims.[238] Fundamentally, this chapter is also about a directional change in law from rules and regulations designed solely to protect the rights of individuals in the exploitation of groundwater towards a system of law that also values public and future rights in groundwater. This subtle shift has been due to several factors including:

(1) the development of technologies that can easily over-utilize the groundwater resource,
(2) the full current exploitation of most groundwater resources in western states,
(3) the scientific understanding of the generally diminishing quality and quantity of groundwater under existing management,
(4) the understanding that one groundwater user can affect the quality and quantity of other groundwater users at great spatial and temporal scales,

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[237] *Commonwealth v. Cyrus Alger* (1851). 61 Mass. 53; 1851 Mass. LEXIS 7; 7 Cush. 53.
Munn v. Illinois (1877). 94 U. S. 113.
[238] For more information see Swenson, E. (1999). "Public Trust Doctrine and Groundwater Rights." University of Miami Law Review 53 U. Miami L. Rev. 363.
Morris, J. P. (2000). "Who Controls the Waters? Incorporating Environmental and Social Values in Water Resources Planning." Hastings West-Northwest Journal of Environmental Law and Policy 6 Hastings W.-N.W. J. Env. L. & Pol'y 117.

(5) constitutional and statutory recognition of the value of groundwater to the public community, and

(6) increased protections for endangered species and surface waters effected by groundwater extraction.

These factors also reflect a fundamental change in how the groundwater resource is valued by private individuals and the public at large. Traditional approaches to groundwater law have tended to protect the private landowner's right to extract without any concern of the damage incurred by other users, the public, or other resources such as surface water. In the case of California, these traditional approaches can be defined as the generally narrow exercise by the SWRCB of the reasonable use provisions of the California Constitution and of the limited use of non-degradation provisions of law such as SWRCB Resolution 68-16. The SWRCB has rarely exercised authority to protect public interests at large without litigation.

This dichotomy of values was also at the center of debate surrounding the decision of the United States Supreme Court in Lucas v. South Carolina Coastal Council, (1992).[239] The question was stated directly by one author as:[240]

> Are environmental regulations that require maintenance of natural conditions significantly new and different from traditional regulations? If so, how should the law respond?

In the Lucas case, Justice Scalia's majority opinion viewed regulations that required a landowner to maintain property in its natural state as a Constitutional taking. The basis for this outcome was that traditional property law views undeveloped land and groundwater as valueless. It ignores the value of ecosystem function. In the case of groundwater, it fails to take into account that the soil matrix is a filter and storage container for groundwater and

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[239] *David H. Lucas v. South Carolina Coastal Council* (1992). 505 U.S. 1003; 112 S. Ct. 2886; 120 L. Ed. 2d 798; 1992 U.S. LEXIS 4537.

[240] Sax, J. L. (1993). "Property Rights and the Economy of Nature: Understanding Lucas v. South Carolina Coastal Council." Stanford Law Review 45(1433).

that groundwater provides valuable baseflow for distant rivers. More importantly, it ignores the public interest in these ecosystem services. The failure of the United States Supreme Court to recognize this value led to the somewhat myopic outcome. It is this traditional view of property that has perhaps limited actions by the SWRCB and other agencies to protect groundwater.

Legislative direction is perhaps the best corrective mechanism for altering this tradition in California. Other states have worked toward this more inclusive view of property by implementing several mechanisms, including monitoring, regional planning, public participation and education, and permitting. The following chapter will examine how these mechanisms have been developed in several states, as well as obstacles to their implementation.

Chapter V. Groundwater Law in Arizona, Colorado, Nebraska, New Mexico, and Texas

"A State's power to regulate the use of water in times and places of shortage for the purpose of protecting the health of its citizens— and not simply the health of its economy— is at the core of its police power."[241]

California's dilemma seems an unsolvable problem of changing the course of a large economy where cities and agriculture have become accustomed to a particular pattern of water allocation and an unmanaged groundwater system in much of the state. The reluctance of the California State Legislature to pass groundwater legislation over the past several decades has only increased the uncertainty of groundwater rights and made the implementation of any future legislation all the more complex. In contrast, other states of the arid west have demonstrated great creativity in reworking groundwater management within a developed economy. Every state presented here (in addition to several other states examined) has within the past 50 years, engaged in a significant overhaul of groundwater management, putting in place protective measures involving some degree of governmental control. This has strangely occurred everywhere but California; yet no other state is more dependent on groundwater in terms of quantity and spatial distribution. Therefore, Arizona, Colorado, Nebraska, New Mexico, and Texas have been selected to serve as case studies in "imaginative new approaches." Although none of these approaches has proven to be a miraculous solution and despite the obstacles remaining, California's inaction is perhaps the best example of opportunity passed over.[242]

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[241] *Sporhase et al. v. Nebraska Ex Rel. Douglas, A. G.* (1982). 458 U.S. 941; 102 S. Ct. 3456; 1982 U.S. LEXIS 13; 73 L. Ed. 2d 1254; 50 U.S.L.W. 5115; 12 ELR 20749.

[242] As early as the 1930s, Henry Holsinger, the head of the State Water Rights Commission called for groundwater legislation Holsinger, H. (1936). Comments pertaining to some fundamental theories of California water law.
Holsinger, H. (1954). Statement by ... on the subject of ground-water legislation to Joint Legislative Interim Committee on Water Problems for its meeting at Los Angeles, California, December 14, 1954. by Henry Holsinger, Principal Attorney, Division of Water Resources: The Division.
Holsinger, H. (1956). Legal aspects of ground-water sources. Sacramento: State Water Rights Board.

	Agricultural Water Use*					Domestic and Commercial Water Use*					
State	Land Irrigated (thousands of acres)	Groundwater	Surface Water	Total	Groundwater %	Population	Groundwater	Surface Water	Public Supply Deliveries (Surface and Groundwater)	Total	Grand Total
Arizona	1,348	2,330	3,710	6,040	39%	3,665	55	-	702	757	6,797
California	9,481	12,200	19,500	31,700	38%	29,760	301	317	5,080	5,698	37,398
Colorado	3,552	2,890	10,200	13,090	22%	3,294	30	1	615	646	13,736
Nebraska	6,853	5,000	1,990	6,990	72%	1,578	53	-	211	264	7,254
New Mexico	984	1,560	1,840	3,400	46%	1,515	45	1	260	306	3,706
Texas	6,225	6,380	3,400	9,780	65%	16,986	161	12	2,720	2,893	12,673

*Usage amounts are in thousands of acre-feet

Figure 19: Groundwater as a Source of Agricultural and Domestic/Commercial Water Supplies[243]

Although these regions are located in predominantly arid parts of the western United States, patterns of water use differ quite substantially. These patterns of use have perhaps affected the development of groundwater management systems. In particular, it is interesting to note which states have a significant dependence on groundwater as a source of drinking water. Groundwater withdrawals in some states account for nearly 100 percent of the drinking water supply, likely a motivational factor in protecting both quality and quantity (see Figure 19).

These case studies will serve several important purposes: (1) demonstrate state constitutional provisions empowering the state to protect public resources (2) identify institutional arrangements that foster groundwater protection, (3) identify monitoring

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Holsinger, H. and Department of Water Resources (1956). Legal aspects of ground-water basins: Department of Water Resources.

Holsinger, H. and Department of Water Resources (1956). Required ground-water legislation: Department of Water Resources.. Many of these early recommendations were comprehensively reviewed and restated at the time of the Governor's Commission to Review Water Rights Law and again the state legislature failed to act Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.

Lambert, D. A. d. (1984). "District Management for California's Groundwater." Ecology Law Quarterly 11 Eco. L. Quart. 373..

[243] Adapted from Solley, W. B., et al. (1998). Estimated Use of Water in the United States in 1995: USGS Circular 1200. Reston, VA: U.S. Geological Survey.

requirements, (4) determine levels of administrative authority, (5) assess substantive goals (e.g. groundwater mining or 100-year goals), (6) address the intermingling of groundwater quantity and groundwater quality issues, and (7) determine approaches to reducing overdraft or contamination (e.g. pump taxes or withdrawal limits). The result will be a collection of strategies from which California could learn and develop strategies to reform the current system.

A. Arizona Groundwater Management

1. Background

The law of Arizona is quite similar to that of California with respect to groundwater.[244] However, riparian rights in surface water are not recognized by the state constitution.[245] Arizona recognizes three separate classes of water resources: surface water, water flowing in definite underground channels, and percolating groundwater. The first two classes are deemed public property by law and governed by the doctrine of prior appropriation. The third class, percolating groundwater, is governed by the rule of reasonable use.[246]

The major sources of water supply in Arizona include surface water from in-state streams, Colorado River water transported over 482 kilometers (300 miles) to Central Arizona via the Central Arizona Project, groundwater, and treated wastewater. Long-term surface water supply is estimated at 5.0 cubic kilometers (4.1 MAF) per year, including 1.8

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[244] Sax, J. L. (2002). Review Of The Laws Establishing The SWRCB's Permitting Authority Over Appropriations Of Groundwater Classified As Subterranean Streams And The SWRCB's Implementation Of Those Laws. Sacramento: State Water Resources Control Board.

[245] Article 17. Section 1. The common law doctrine of riparian water rights shall not obtain or be of any force or effect in the state. 2. Recognition of existing rights Section 2. All existing rights to the use of any of the waters in the state for all useful or beneficial purposes are hereby recognized and confirmed.

[246] Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688.

cubic kilometers (1.5 MAF) of Colorado River and Central Arizona Project water. Groundwater makes up the balance of the supply and more groundwater is pumped than is naturally recharged, resulting in a condition of overdraft. This condition of overdraft was the primary motivating factor in the passage of groundwater legislation.[247]

2. Arizona Groundwater Management Act of 1980

a. History, Policy Declaration and Goals

As early as 1943, the USGS authored a report outlining the need for a groundwater code in Arizona that controls overdrafting. Early on, the Ground Water Act of 1948 froze the expansion of agriculture in basins experiencing critical levels of overdraft. In a decision of note, the Arizona Supreme Court in Bristor v. Cheatham (1952) found groundwater to be public property and thus subject to prior appropriation, however, the court reversed itself less than a year later in Bristor v. Cheatham (1953).[248] Despite efforts in the legislature to expand the scope of groundwater management, no new legislation passed until 1980. However, the period was marked with a few important court decisions that upheld the existing regulation of groundwater as a constitutional use of the state's police powers.[249]

One of the motivating factors in the creation of a new groundwater law was the Central Arizona Project.[250] Recognizing the severity of the state's overdraft problem, U.S. Congressional support for the funding of the Central Arizona Project hinged on Arizona's

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[247] Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688.

[248] *Bristor et al. v. Cheatham et al.* (1952). 73 Ariz. 228; 240 P.2d 185; 1952 Ariz. LEXIS 237.
Bristor et al. v. Cheatham et al. (1953). 75 Ariz. 227; 255 P.2d 173; 1953 Ariz. LEXIS 206.

[249] Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688.

[250] The Central Arizona Project is designed to supply about 1.5 million acre-feet of Colorado River water per year to Pima, Pinal and Maricopa counties. The Central Arizona Project carries water from Lake Havasu near Parker to near Tucson. It is a 336-mile long system of aqueducts, tunnels, and pumping plants.

ability to draft laws to curtail groundwater pumping once the project was completed. Arizona's response was the Arizona Groundwater Management Act.

In 1979, a new groundwater commission of gubernatorial appointees convened and drafted a new Arizona Groundwater Management Code.[251] It was introduced into the state legislature on June 5, 1980, passing both houses the same day. The following day it was signed by the governor. Town of Chino Valley v. City of Prescott (1981) upheld the constitutionality of the act.[252] The quickness with which the legislation was passed illustrates the influence that the federal purse plays in state groundwater management.

b. Actors, Purposes, Powers, and Jurisdiction

The Arizona Department of Water Resources (ADWR) was created in 1980 and entrusted with the responsibilities of implementing the Groundwater Code and managing long-term water supply. The Code sets restrictions on the uses of groundwater, by creating Irrigation Non Expansion Areas (INAs) and Active Management Areas (AMAs) in critical areas of the state (see Figure 20).[253]

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[251] Declaration of policy of the Arizona Groundwater Code (45-401)
A. The legislature finds that the people of Arizona are dependent in whole or in part upon groundwater basins for their water supply and that in many basins and sub-basins withdrawal of groundwater is greatly in excess of the safe annual yield and that this is threatening to destroy the economy of certain areas of this state and is threatening to do substantial injury to the general economy and welfare of this state and its citizens. The legislature further finds that it is in the best interest of the general economy and welfare of this state and its citizens that the legislature evoke its police power to prescribe which uses of groundwater are most beneficial and economically effective.
B. It is therefore declared to be the public policy of this state that in the interest of protecting and stabilizing the general economy and welfare of this state and its citizens it is necessary to conserve, protect and allocate the use of groundwater resources of the state and to provide a framework for the comprehensive management and regulation of the withdrawal, transportation, use, conservation and conveyance of rights to use the groundwater in this state.
[252] *Town of Chino Valley v. The City of Prescott* (1981). 131 Ariz. 78; 638 P.2d 1324; 1981 Ariz. LEXIS 276.
[253] Arizona Department of Water Resources (1999). Third Management Plan 2000-2010 Phoenix Active Management Area. Phoenix: State of Arizona.

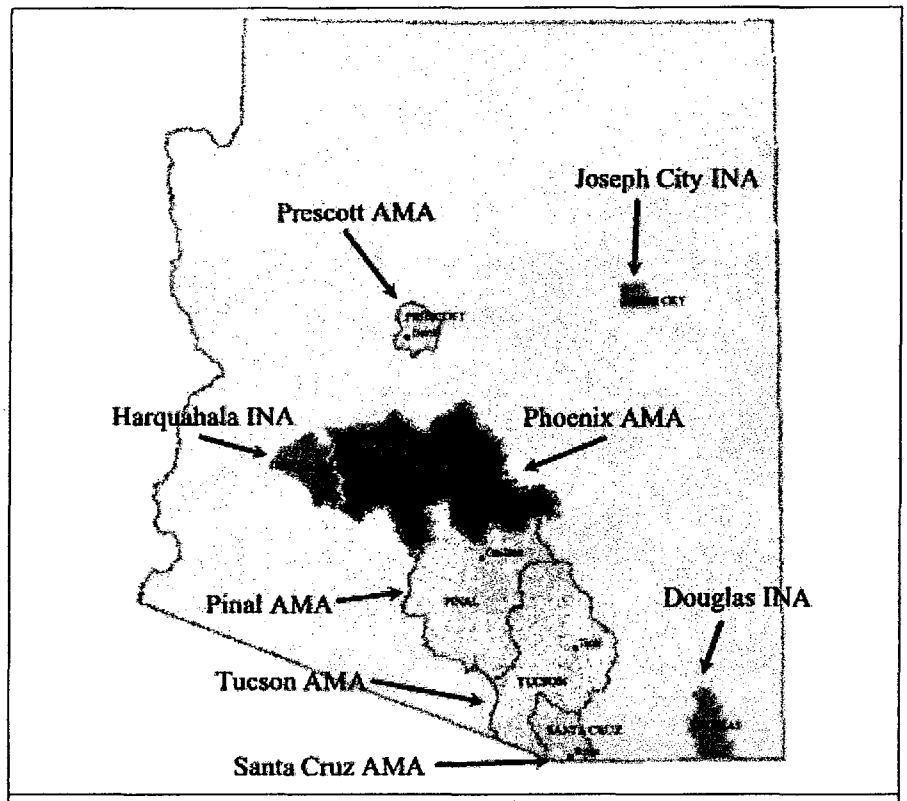

Figure 20: Active Management Areas in Arizona[254]

Areas where groundwater depletion is most severe are designated as AMAs. There are currently five AMA's: Pinal, Phoenix, Prescott, Santa Cruz, and Tucson. The goal in each AMA, except for the Pinal AMA, is safe yield by the year 2025. In the Pinal AMA, dominated by an agricultural economy, the management goal is to "preserve that economy for as long as possible." Consideration is also given to the need to preserve groundwater for future non-irrigation uses. In INAs, irrigated acreage is restricted but specific water conservation measures are not required. There are three INAs in the state, Douglas, Harquahala, and Joseph City.

Eighty percent of the state population resides in the AMAs. AMAs are areas of excessive groundwater overdraft and specific water conservation measures are required in these areas. In addition, in AMAs, groundwater withdrawal requires a right or permit. This

[254] Adapted from the Arizona Department of Water Resources.

is often an Irrigation Grandfathered Right (IGR), which gives a user the right to withdraw and use groundwater for irrigation purposes. Lands located in an AMA cannot be irrigated without this right which is attached to the land (there is a 10-acre exemption).

c. Monitoring, Management, and Decision-making

Groundwater management authority is vested in the ADWR.[255] ADWR has an extensive array of regulatory tools to meet the management goals of AMAs. These tools include:

(1) water rights components of the Code,
(2) assured water supply provisions for new developments,
(3) underground storage tank and recovery protections,
(4) permitting requirements and stipulations,
(5) well-spacing requirements,
(6) conservation assistance programs,
(7) water use reporting requirements, and
(8) enforcement authority.

After more than 20 years following enactment, the Arizona Groundwater Code has had great influence on management activities. State law provides for an annual assessment on most of the wells pumping groundwater for irrigation. Owners of non-exempt wells within AMAs and INAs must use approved measuring devices and submit Annual Groundwater Withdrawal reports to ADWR.[256] Users withdrawing groundwater from non-exempt wells within AMAs must pay an annual groundwater withdrawal fee. The

[255] ADWR also: administers and enforces Arizona's groundwater code, and surface water rights laws (except those related to water quality); negotiates with external political entities to protect Arizona's Colorado River water supply; oversees the use of surface and groundwater resources under state jurisdiction, and represents Arizona in discussions of water rights with the federal government. In addition, the Department explores methods of augmenting water supplies to meet future demands, and develops policies that promote conservation and equitable distribution of water. The Department also inspects dams and participates in flood control planning to prevent property damage, personal injury, and loss of life. In support of these activities, ADWR collects and analyzes data on water levels and on water-quality characteristics.
[256] There is an exemption for wells with a capacity of less than 35 GPM.

withdrawal fee and annual groundwater withdrawal and use reports are to be filed annually in March. Under new legislation establishing the Arizona Water Banking Authority (AWBA),[257] these annual withdrawal fees will increase slightly to help finance the AWBA's efforts. However, groundwater use outside of the AMAs is not regulated and no permit is required. However, drilling a well anywhere in the state requires that a "Notice of Intent to Drill" be filed with ADWR.

In INAs, users that irrigate land must have a Notice of Irrigation Authority (NIA) from the ADWR. NIAs in the Joseph City and Douglas INAs, as well as IGRs in all AMAs were established during the five-year period before January 1, 1980 and NIAs in the Harquahala Valley INA were established during the five-year period before January 6, 1981. All rights are based on irrigation utilization during those periods. The Groundwater Code prohibits the development of new irrigated acres within AMAs and INAs.

ADWR has created several conservation requirements and guidelines for agricultural water users. A maximum annual groundwater allotment has been established, controlling the amount of water that may be utilized each year to irrigate all or any portion of a farm. This allotment is determined by multiplying a farm's "water duty acres" by its "water duty." "Water duty acres" is the highest number of acres in a farm irrigated during any one year from 1975-1980. A "water duty" is the amount of water allotted to a farm to raise the crops historically grown.

A flex account has been established which allows a farmer to "bank" a portion of his annual allotment not utilized in a given year. This balance can then be utilized in future

[257] The AWBA was created to store unused Arizona Colorado River water to meet future needs for: (1) Assuring adequate supply to municipal and industrial users in times of shortages or disruptions of the CAP system; (2) Meeting the management plan objectives of the Arizona Groundwater Code; (3) Assisting in the settlement of Indian water rights claims; and (4) Exchanging water to assist Colorado River communities.

years. Currently, over 12 cubic kilometers (10 MAF) have been banked in the state. A farmer may also withdraw water from the bank if the annual allotment in one year will not meet the farm's requirements. However, the farmer must not already have a negative balance in the farms flex account. There is no limit to the amount of water a farmer may bank, however the annual groundwater allotment cannot be exceeded by more than 50 percent. Substantial conservation requirements also exist for municipal and industrial uses.

Currently Arizona does not utilize its full 3.4 cubic kilometers (2.8 MAF) share of Colorado River water. ADWR projects that the state will not fully utilize the resources until the year 2030.

d. Regional and Long-term Planning

The Code defines five separate management periods for planning purposes. Each planning period has specific water quantity goals, the final goal being safe yield. The periods are defined as follows:

- First Management Plan: 1980-1990
- Second Management Plan: 1990-2000
- Third Management Plan: 2000-2010
- Fourth Management Plan: 2010-2020
- Fifth Management Plan: 2020-2025

Arizona recently finished developing its Third Management Plan. Within the plan are specific programming initiatives to attain safe-yield. The ADWR also promulgated several general management principles that were identified as important to the planning process.[258] These management principles are:

[258] Arizona Department of Water Resources (1999). Third Management Plan 2000-2010 Phoenix Active Management Area. Phoenix: State of Arizona.

- The authorities granted to ADWR must be integrated into a comprehensive strategy for meeting the management goals of the AMA. The ADWR has several tools available to meet the management goal; these include water rights provisions, underground storage, conservation programs, and several others.
- Effective water management must include both supply augmentation and demand management. Arizona, as with California, has substantially diminished capabilities to increase supply. Therefore, demand-side management is necessary.
- Effective and efficient water management must establish a long-term perspective and be regional in scope. ADWR has interpreted the Code as imparting responsibility on itself for assuring future supplies. Thus, ADWR is well aware of the needs in long-term planning. Such planning language could also have applicability to other states.
- Water users must have an integral role in management program development and implementation. Although most decision-making authority is vested with ADWR, the ADWR has made provisions for including water users in the decision-making process as a means of promoting successful implementation.
- All water sources need to be included in any long-term, comprehensive water management strategy. This is perhaps one of the more important aspects of successful water management in arid regions and one of the more complex legal challenges.[259] Arizona, as with California, observes a very distinct legal history with respect to surface water and groundwater. They have been historically managed as separate resources despite the preponderance of scientific evidence that espouses their interconnectedness.
- Water management efforts must consider economic impacts and feasibility.
- Educating the public on water issues and involving the public in developing management programs is essential to building and sustaining an effective water management effort.
- Water management efforts should be consistent with, and enhance, the quality of life in the community.
- Water supplies available today must be used to meet the needs of the future.

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[259] Glennon, R. J. and I. Thomas Maddock (1994). "In Search of Subflow: Arizona's Futile Effort to Separate Groundwater from Surface Water." Arizona Law Review 36 Ariz. L. Rev. 567.

- Water management programs should provide a stable institutional framework that creates an environment of certain in water resource decision-making.
- Local water management issues must be addressed as regional and statewide strategies are developed.
- Water management programs should be based on the premise that the future issues are unlikely to be the same as those that have been encountered in the past, and that the pace of change is likely to increase.

As basic as these principles appear, many are absent from the planning process in California. For instance, no effort is made to regionally coordinate groundwater extraction or protection. Principles such as these might provide a strong foundation for future groundwater policy in other states.

In addition to ADWR's creation of general management principles, ADWR has also authored very specific objectives for this planning cycle. Setting specific quantifiable goals is an important part of quality and quantity management. Many states have language that ambiguously sets targets, making success or failure difficult to detect. These objectives include:

- The establishment and implementation of Third Management Plan water conservation and groundwater replenishment requirements.
- The expansion of public assistance and public education to reach more of the public.
- The encouragement of coordination on the part of ADWR among the agencies that have a role in quality and quantity aspects of water policy, such as the Arizona Water Banking Authority (AWBA) and Arizona Department Of Environmental Quality (ADEQ).
- The collection, analysis, and maintenance of data by ADWR to provide necessary information to identify water management issues and propose solutions.

3. Summary of Arizona Groundwater Management Act of 1980

The groundwater law of Arizona is an example of a highly centralized form of groundwater allocation control. The state government, through ADWR, has extensive authority to limit pumping, except in the previous mentioned cases where grandfathered rights apply. There is local involvement of water users, but it seems limited, at least statutorily, to public comment on proposed actions and other recommendatory procedures.

The most significant advantages of such a system are the ability to force different users to comply, with the goal of attaining safe-yield for the total system. Planning is made easier by eliminating new groundwater usage in many basins, something not found in many regions of California where a well can be drilled and pumped even if the basin is in a state of overdraft. Other mandatory programs also encourage conservation and reduce demand.

This approach also has several disadvantages and obstacles. Concentration of authority increases monitoring, planning, and administrative requirements on a single state agency, thus AWDR budget with respect to groundwater management must be substantial to accomplish its duties. Concerns might also arise over the equitability of cutbacks in water use by various parities. How responsibilities are partitioned for water use reductions is a contentious issue. This issue is all the more intense given the nature of grandfathered rights that are exempt from many of the cutbacks along with the inclusion of new exemptions for municipal water supplies.[260] Additionally, there are still several remaining questions regarding the interrelation of surface water and groundwater in Arizona. Questions

[260] Glennon, R. (2002). Telelphone Interview.

pertaining to how to address situations when surface water appropriations affect groundwater level have not been fully addressed.[261]

[261] Glennon, R. J. and I. Thomas Maddock (1994). "In Search of Subflow: Arizona's Futile Effort to Separate Groundwater from Surface Water." Arizona Law Review 36 Ariz. L. Rev. 567.
Governor's Water Management Commission (2001). Governor's Water Management Commission: Final Report. Phoenix: State of Arizona.

B. Colorado Groundwater Management

1. Background

Article XVI[262] of the Colorado Constitution states that water of streams is public property and that the general assembly of Colorado has the obligation to protect interest of the state in natural streams.[263] This results in a public interest in preserving water resources.[264] In Colorado River Water Conservation Dist. v. Vidler Tunnel Water Co. (1979), the court further stated that: "This section guarantees right to appropriate, not a right to speculate, and the right to appropriate is for use, not merely for profit."[265] The court reasoned as early as 1912 that the state is justified in asserting ownership of all natural streams.[266] This was based on the fact that all natural streams of Colorado are nonnavigable, thus not under the purview of the federal government. Therefore, Colorado recognizes only appropriation (usufruct) rights to surface water.

Colorado generally recognizes two classes of groundwater: tributary and percolating. First, there is a presumption that all groundwater is tributary to some stream. Since seepage and percolation waters belong to the river they belong to the people of the state Nevius v. Smith, (1929).[267] In Nevius v. Smith, the court stated:

> The argument of defendants, based on decisions from other states, that percolations belong to the owner of the soil is unsound in Colorado. Ever since *Comstock v. Ramsay,* 55 Colo. 244, 133 Pac. 1107, we have held that seepage and percolation belong to the river, and have gone so far, though against the judgment of the writer, as to hold that one may not recapture leakage from his own reservoir. *Rio Grande Co. v. Wagon Wheel Gap Co.,* 68 Colo. 437, 191

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262 ARTICLE XVI - Mining and Irrigation Art, Section 5.
Water of streams public property. The water of every natural stream, not heretofore appropriated, within the state of Colorado, is hereby declared to be the property of the public, and the same is dedicated to the use of the people of the state, subject to appropriation as hereinafter provided.
263 *Stockman v. Leddy* (1912). 55 Colo. 24; 129 P. 220; 1912 Colo. LEXIS 349.
264 *Wadsworth v. Kuiper* (1977). 193 Colo. 95; 562 P.2d 1114; 1977 Colo. LEXIS 588.
265 *Colorado River Water Conservation Dist. v. Vidler Tunnel Water Co.* (1979). 197 Colo. 413, 594 P.2d 566.
266 *Stockman v. Leddy* (1912). 55 Colo. 24; 129 P. 220; 1912 Colo. LEXIS 349.
267 *Nevius et al. v. Smith* (1928). 86 Colo. 178; 279 P. 44; 1928 Colo. LEXIS 411.
See also *Comstock v. Ramsay* (1913). 55 Colo. 244; 133 P. 1107; 1913 Colo. LEXIS 257.

Pac. 129. See also, *Durkee Ditch Co. v. Means,* 63 Colo. 6, 164 Pac. 503; *Trowell Co. v. Bijou Dist.,* 65 Colo. 202, 176 Pac. 292; *Fort Morgan Co. v. McCune,* 71 Colo. 256, 206 Pac. 393; and since it belongs to the river it belongs to the people of the state by article 16, section 5 of her Constitution.

These cases refute any claim that percolation or seepage of any water belongs to the land owner, and fix the principle that any appropriation of it must be subject to all prior appropriations from the river, which seems in accord with the main part of the above quoted statute, but are contrary to the proviso thereof.

If it be claimed that we cannot establish a rule contrary to a statute, we answer that it is true, but since the Constitution gives the river water to the people, subject to appropriation, and since the seepage belongs to the river it belongs to the people by force of the Constitution and the statute cannot transfer it and it must be subject to appropriations as river water.

Second, if it is not tributary to the natural stream, it is not subject to the law of appropriation (see Figure 21 for non-tributary groundwater basins).[268] In these areas of percolating waters, basins can be designated to introduce groundwater management. Importantly, the Ground Water Management Act was not found to be unconstitutional, insofar as said act applies to tributary ground water.[269]

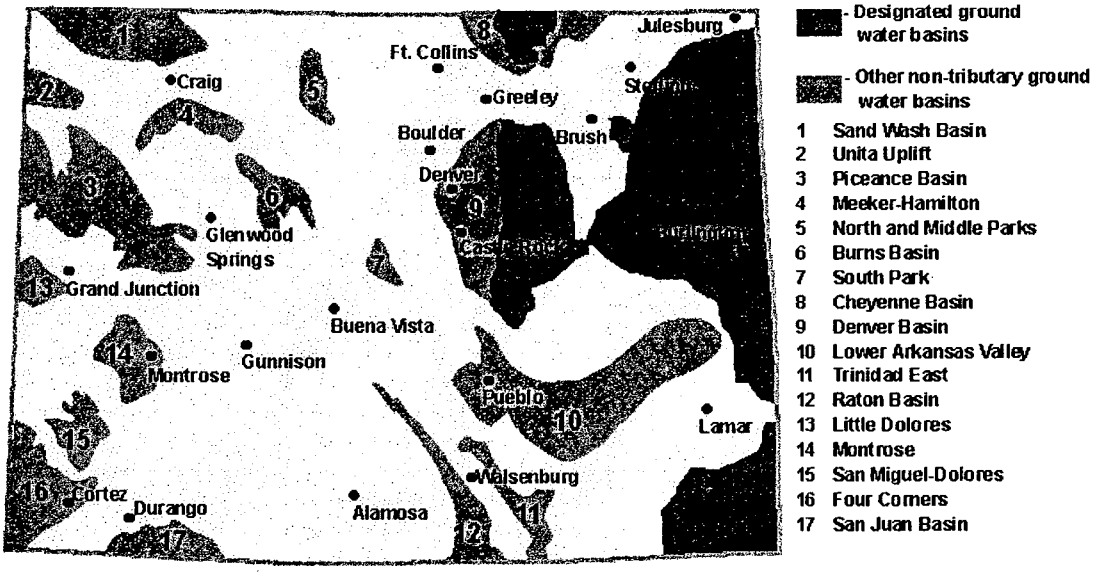

Figure 21: Non-tributary Groundwater Basins

[268] *Whitten v. Coit* (1963). 153 Colo. 157; 385 P.2d 131; 1963 Colo. LEXIS 297.
[269] *Kuiper v. Lundvall* (1974). 187 Colo. 40; 529 P.2d 1328; 1974 Colo. LEXIS 638.

2. Colorado Groundwater Management Act of 1965

a. History, Policy Declaration and Goals[270]

The Colorado Ground Water Management Act of 1965 governs the administration of groundwater in Colorado.[271] Groundwater in designated basins (percolating groundwater) is managed by the Groundwater Commission while non-designated groundwater (tributary groundwater) is managed by the State Engineer and the Water Court. Groundwater basins may be designated if:

(1) groundwater in its natural course would not be available to and required for the fulfillment of decreed surface rights and

(2) it is not adjacent to a continuously flowing natural stream, wherein groundwater withdrawals have constituted the principal water usage for at least 15 years prior to the proposed designation of the basin.

Upon designation of a basin, a water management district may be formed (see Figure 22 for designated basins and groundwater management districts). In designated basins, wells

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[270]Colorado Ground Water Management Act Legislative declaration (37-90-102) 1963
(1) It is declared that the traditional policy of the state of Colorado, requiring the water resources of this state to be devoted to beneficial use in reasonable amounts through appropriation, is affirmed with respect to the designated ground waters of this state, as said waters are defined in section 37-90-103 (6). While the doctrine of prior appropriation is recognized, such doctrine should be modified to permit the full economic development of designated ground water resources. Prior appropriations of ground water should be protected and reasonable ground water pumping levels maintained, but not to include the maintenance of historical water levels. All designated ground waters in this state are therefore declared to be subject to appropriation in the manner defined in this article.
(2) The general assembly finds and declares that the allocation of nontributary ground water pursuant to statute is based upon the best available evidence at this time. The general assembly recognizes the unique, finite nature of nontributary ground water resources outside of designated ground water basins and declares that such nontributary ground water shall be devoted to beneficial use in amounts based upon conservation of the resource and protection of vested water rights. Economic development of this resource shall allow for the reduction of hydrostatic pressure levels and aquifer water levels consistent with the protection of appropriative rights in the natural stream system. The doctrine of prior appropriation shall not apply to nontributary ground water. To continue the development of nontributary ground water resources consonant with conservation shall be the policy of this state. Such water shall be allocated as provided in this article upon the basis of ownership of the overlying land. This policy is a reasonable exercise of the general assembly's plenary power over this resource.
[271] Simpson, H. D. and State of Colorado Groundwater Commission (2001). Rules and Regulations for the Management and Control of Designated Ground Water: 2 CCR 410-1. Denver, Colorado: State of Colorado.

permits are required from the Commission and the Commission hears all disputes regarding groundwater rights.

Within the Groundwater Management Act, a distinction between tributary and non-tributary groundwater is also made. Groundwater is considered tributary if it is hydraulically connected to a surface stream in such a way that if pumped the well will deplete the flow of the natural stream within 100 years to the extent of one-tenth of one percent of the rate of withdrawal, a so called "bright line" test. Tributary groundwater is governed by the rules of the prior appropriation doctrine; applicants must apply to the State Engineer to obtain a permit to recognize their right.

Non-tributary groundwater is found outside of designated groundwater basins and is not connected hydraulically to surface streams. The determination of non-tributary is based on aquifer conditions at the time of the permit application. Appropriation does not apply to non-tributary groundwater. Groundwater in such situations is apportioned based on overlying land ownership.

b. Actors, Purposes, Powers, and Jurisdiction

The appropriation of groundwater requires the submittal of an application to the Ground Water Commission if in a designated basin or to the State Engineer in other areas. The name of the groundwater basin, beneficial use for which the water will be used, well location, annual water amount requested, maximum pumping rate, and the type of land to be irrigated should all be included in the application. In evaluating the application, the Commission examines the location and geologic conditions, the average annual yield and recharge rate of the appropriate water supply, the priority and quantity of existing claims of all persons to use the water, and the proposed method of use. It is also obligatory that new

permits not impair existing water rights. Impairment therein is defined as the unreasonable lowering of the water level, or the unreasonable deterioration of water quality. Applicants have the burden of proof for showing that their proposed well will not injure existing rights.

Since both the Commission and State Engineer have enforcement authority of the regulations established under the act and are the real and substantial parties in interest in an action to enjoin enforcement of water control measures, they can be parties to suits brought

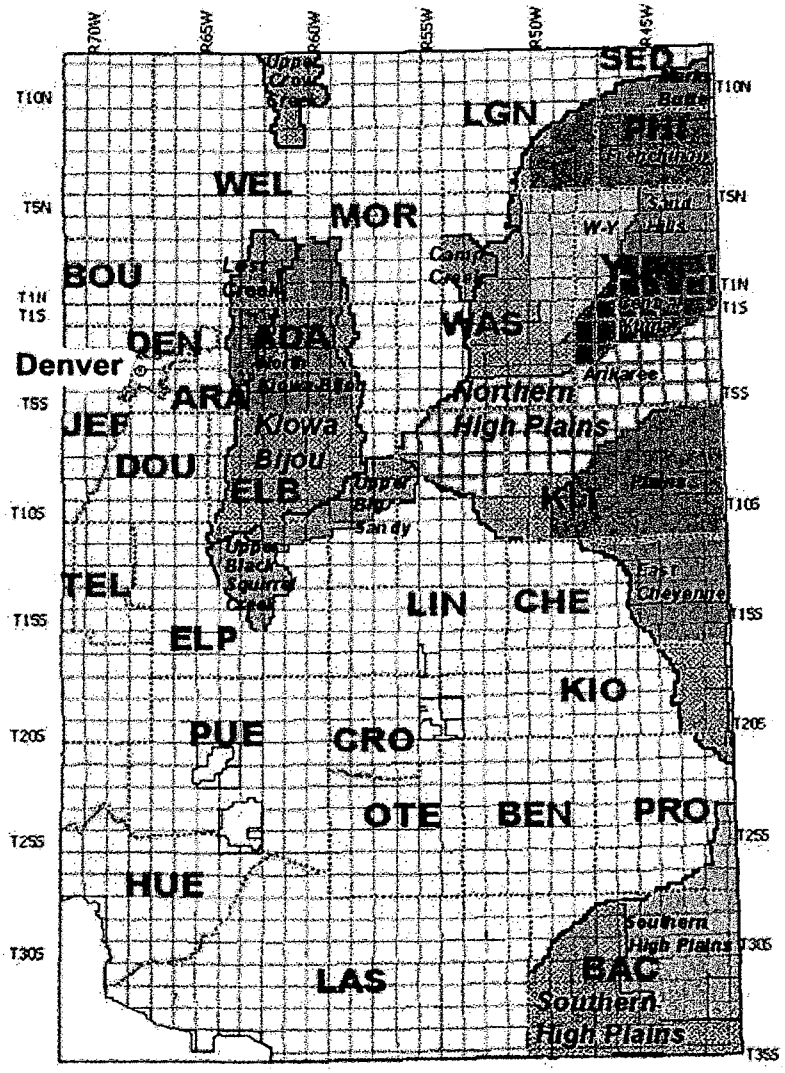

Figure 22: Designated Groundwater Basins in Colorado (Eastern Portion of the State)

by water users.[272]

Within areas determined as designated ground water basins, groundwater management districts may be formed; however, no district can be organized unless all groundwater aquifers containing designated ground water within the district have been included as a part of the district by the commission.

Once a basin is so designated, the act gives tax-paying electors in the designated area the right to create ground water management districts within the basin, so any district thus formed, if approved by the commission, is a governmental subdivision of the State of Colorado, and a corporate body with the powers of a public or municipal corporation.[273] Formation of ground water management districts is optional.[274]

Specific powers and authorities of the major actors are referenced below:

(1) Groundwater Commission[275]

> (1) In the administration and enforcement of this article and in the effectuation of the policy of this state to conserve its designated ground water resources and for the protection of vested rights and except to the extent that similar authority is vested in ground water management districts pursuant to section 37-90-130 (2), the ground water commission is empowered:
>
> (a) To supervise and control the exercise and administration of all rights acquired to the use of designated ground water. In the exercise of this power it may, by summary order, prohibit or limit withdrawal of water from any well during any period that it determines that such withdrawal of water from said well would cause unreasonable injury to prior appropriators; except that nothing in this article shall be construed as entitling any prior designated ground water appropriator to the maintenance of the historic water level or any other level below which water still can be economically extracted when the total economic pattern of the particular designated ground water basin is considered; and further except that no such order shall take effect until six months after its entry.
>
> (b) To establish a reasonable ground water pumping level in an area having a common designated ground water supply. Water in wells shall not be deemed available to fill the water

[272] *Jackson v. State of Colorado* (1968). 294 F. Supp. 1065; 1968 U.S. Dist. LEXIS 8042.
[273] *North Kiowa-Bijou Management District v. Ground Water Commission of the State of Colorado* (1973). 180 Colo. 313; 505 P.2d 377; 1973 Colo. LEXIS 847.
[274] *Cherokee Water District v. Ground Water Commission of the State of Colorado* (1978). 196 Colo. 192; 585 P.2d 586; 1978 Colo. LEXIS 570.
[275] 37-90-111 - Powers of the ground water commission - limitations.

right therefor if withdrawal therefrom of the amount called for by such right would, contrary to the declared policy of this article, unreasonably affect any prior water right or result in withdrawing the ground water supply at a rate materially in excess of the reasonably anticipated average rate of future recharge.

(c) To issue permits for the construction of replacement wells. Any permits issued shall set forth the conditions under which a well may be modified by a change of the well itself or the pumping equipment therefor, by the drilling of a replacement well, or otherwise, in order to make it possible for the owner of a well to obtain the water to which such owner may be entitled by virtue of his original appropriation.

(d) In the exercise of any of the powers or duties conferred by this section, to confer and consult with the board of directors of the ground water management district board in the affected area, if any such board exists, before promulgating any orders or regulations which would affect the district in general;

(e) To order the total or partial discontinuance of any diversion within a ground water basin to the extent the water being diverted is not necessary for application to a beneficial use;

(f) In any area where a ground water management district has not been formed, to prescribe satisfactory and economical measuring methods for the measurement of water levels in and the amount of water withdrawn from wells and to require reports to be made at the end of each pumping season showing the date and water level at the beginning of the pumping season, the date and water level at the end of the pumping season, and showing any period of more than thirty days' cessation of pumping during such pumping season;

(g) Upon application therefor by any permit holder, to authorize a change in acreage served, volume of appropriation, place, time, or type of use of and by any water right, or of any well location, either conditional or final, granted under the authority of the commission but only upon such terms and conditions as will not cause material injury to the vested rights of other appropriators. No such change that increases the volume of appropriation beyond that authorized by the original decree, conditional permit, registration statement, or other well permit issued prior to basin designation shall be authorized, and no such change shall be approved until after publication of such application as provided in section 37-90-112; except that publication shall not be required to approve a temporary change pursuant to the rules adopted by the commission and except that publication shall not be required for replacement wells that are relocated no further than the maximum distance allowed by district rules and regulations without prior board approval or by commission policy where no district exists or where no district rule has been adopted.

(h) To adopt rules necessary to carry out the provisions of this article.

(2) No supplemental wells or alternate point of diversion wells shall be allowed in any area of any designated ground water basin in which the proposed well or wells combined would deplete the aquifer in excess of the rate of depletion prescribed by the ground water commission or by the ground water management district rules and regulations.

(3) In the exercise of any of the powers or duties conferred by this section, the commission shall confer and consult with the board of directors of the ground water management district board in the affected areas, if any such board exists, before promulgating any orders or regulations which would affect the district in general, and shall request written recommendations from the board of any existing district within which the conditional or

final permit has been issued, before taking final action on any request or application made pursuant to this section.

(4) In any area within a designated ground water basin which has not been included within the boundaries of a ground water management district, the commission has the authority to exercise any power given by this article to the board of directors of a ground water management district, but, before instituting control measures pursuant to section 37-90-130, the commission shall follow the procedures set out in section 37-90-131.

(5) Notwithstanding any other provision of this article, the commission shall allocate, upon the basis of ownership of the overlying land, any designated ground water contained in the Dawson, Denver, Arapahoe, or Laramie-Fox Hills aquifers. Permits issued pursuant to this subsection (5) shall allow withdrawals on the basis of an aquifer life of one hundred years.

(2) Groundwater management districts[276]

(1) The district board has the duty and responsibility of consulting with the commission on all ground water matters affecting the district to determine whether proposed restrictions or regulations are suitable for such area, to determine in conjunction with the commission whether the area of the district should be enlarged or contracted, to cooperate with the commission and the state engineer in the assembling of data on the ground water aquifers in the area and the enforcement of regulations or restrictions which may be imposed thereon, and to assist the commission and the state engineer to the end of conserving the ground water supplies of the area for the maximum beneficial use thereof.

(2) After the issuance of any well permit for the use of ground water within the district by the ground water commission as provided in sections 37-90-107 and 37-90-108, the district board has the authority to regulate the use, control, and conservation of the ground water of the district covered by such permit by any one or more of the following methods, but the proposed controls, regulations, or conservation measures shall be subject to review and final approval by the ground water commission if objection is made in accordance with section 37-90-131:

(a) To provide for the spacing of wells

(b) To acquire lands for the erection of dams and for the purpose of draining lakes, etc

(c) To develop comprehensive plans

(e) To promulgate reasonable rules and regulations for the purpose of conserving, preserving, protecting, and recharging

(f) To prohibit, after affording an opportunity for a hearing before the board of the local district and presentation of evidence, the use of ground water outside the boundaries of the district where such use materially affects the rights acquired by permit by any owner or operator of land within the district;

(g) Meters;

(4) Enforcement

[276] 37-90-130 - Management districts - board of directors.

The management district is a corporate government subdivision of the state of Colorado which is formed for the purpose of assisting the commission on all matters affecting the district area, which include enforcing commission regulations, providing data on underground aquifers within the area, determining if commission regulations are suitable for the area, and helping conserve the ground water for maximum beneficial use.

(3) Division of Water Resources (State Engineer)[277]

(1) Administration of Surface and Ground Water Rights: The Division is empowered to administer all surface and ground water rights throughout the state and ensure that Colorado's water rights system, the prior appropriation doctrine, is enforced.

(2) Ground Water Well Permitting: By law, every new well in the state that diverts ground water must have a well permit. Over 10,000 applications are submitted for review each year. Staff members must determine the amount of water available and analyze the potential for injury to other existing water rights.

(3) Assists Colorado Ground Water Commission: Staff are provided to evaluate well permit applications before submitting the applications to the Commission for approval.

(4) Assists Board of Examiners of Water Well and Pump Installation Contractors. Staff are provided to aid the Board in overseeing the installation of well pump equipment and regulating well construction in Colorado.

(5) Dam Safety: Dam safety engineers review and the state engineer approves plans and specifications for construction of new dams and plans for repair of existing dams. The engineers also inspect dams and determine the safe storage levels in reservoirs.

(6) Administers Interstate Compacts: The state engineer and staff ensure that Colorado meets the commitments set forth in interstate compacts, federal court decrees, and U.S. Supreme Court Decisions.

(7) Collect and Analyze Water Supply Data: Engineers and geologists collect and analyze water supply data to forecast streamflows, determine diversion requirements, determine evaporation losses, and calculate historic use and current conditions.

(4) State Engineer[278]

(1) In the administration and enforcement of this article and in the effectuation of the policy of this state to conserve its ground water resources and for the protection of vested rights, the state engineer is empowered:

(a) To require all flowing wells to be equipped with valves so that the flow of water can be controlled;

(b) To require both flowing and nonflowing wells to be so constructed and maintained as to prevent the waste of ground waters through leaky wells, casings, pipes, fittings, valves, or pumps, either above or below the land surface;

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[277] Primary Responsibilities of the Division of Water Resources (Office of the State Engineer)
[278] 37-90-110 - Powers of the state engineer.

(c) To go upon all lands, both public and private, for the purpose of inspecting wells, pumps, casings, pipes, fittings, and measuring devices, including wells used or claimed to be used for domestic or stock purposes;

(d) To order the cessation of the use of a well pending the correction of any defect that the state engineer has ordered corrected;

(e) To commence actions to enjoin the illegal opening or excavation of wells or withdrawal or use of water therefrom and to appear and become a party to any action or proceeding pending in any court or administrative agency when it appears that the determination of such action or proceeding might result in depletion of the ground water resources of the state contrary to the public policy expressed in this article or might injure vested rights of other appropriators;

(f) To take such action as may be required to enforce compliance with any regulation, control, or order promulgated pursuant to the provisions of this article.

(5) Colorado Water Quality Control Commission[279]

(1) Adopts water quality classifications and standards for the state.

(2) Creates regulations aimed at achieving compliance with those classifications and standards.

c. Monitoring, Management, and Decision-making

The administration and enforcement of the act is placed in the hands of an administrative commission, the state engineer, and locally formed ground water management districts, and the commission is empowered to designate the ground water basins and to supervise and control the administration of all ground water so designated, it also grants or denies petitions for the formation of management districts within each ground water basin.[280]

The Ground Water Commission consists of twelve members, nine of whom are appointed by the Governor and three others who consist of the Executive Director of the Department of Natural Resources (DNR), the Director of the Colorado Water Conservation Board (CWCB), and the State Engineer. The State Engineer is the Executive Director of the

[279] Primary Responsibilities of the Colorado Water Quality Control Commission
Primary Responsibilities of the Colorado Water Quality Control Division
(1) Enforces Colorado's discharge permit program.
(2) Enforces regulations adopted by the Commission.
[280] Jackson v. Colorado, 294 F. Supp. 1065 (D. Colo. 1968)

Commission, and implements and enforces all decisions, orders, and policies of the Ground Water Commission.[281]

The act provides that the district, along with its powers to enforce commission regulations, has general authority to regulate the use, control, and conservation of ground waters within the district. To accomplish these purposes, the district board of directors has the power to impose upon water users within the district certain rules and regulations, subject to the approval of the commission. The district possesses the power to promulgate regulations relating to the limitation upon exportation of ground waters outside of the district, where such use "materially affects the rights acquired by permit by any owner or operator of land within the district."[282]

To implement this act, conserve designated groundwater resources and for the protection of vested rights, the Ground Water Commission is empowered to engage in several management activities.

The Groundwater Commission must supervise and control the exercise and administration of all rights acquired to the use of designated ground water. This includes prohibiting or limiting withdrawal of water from any well during any period that it determines that such withdrawal of water from a well would cause unreasonable injury to prior appropriators. The Groundwater Commission also has the authority to establish a reasonable ground water pumping level in an area having a common designated ground water supply. This will help alleviate conditions of overdraft in a basin. This coincides with

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[281] Simpson, H. D. and State of Colorado Groundwater Commission (2001). Rules and Regulations for the Management and Control of Designated Ground Water: 2 CCR 410-1. Denver, Colorado: State of Colorado.
[282] *North Kiowa-Bijou Management District v. Ground Water Commission of the State of Colorado* (1973). 180 Colo. 313; 505 P.2d 377; 1973 Colo. LEXIS 847.

the power to order the total or partial discontinuance of pumping within a ground water basin that is not a beneficial use.

In any area where a ground water management district has not been formed, the Commission require the measurement of the water level and the amount extracted. The Commission can also require reports to be made at the end of each pumping season showing the water level at the beginning of the pumping season and the water level at the end of the pumping season.

d. Regional and Long-term Planning

In 1969, the State of Colorado disbanded 70 water districts with seven water divisions organized along major hydrologic boundaries in the state.[283] Each division possesses a water court and a division engineer for adjudicating basins and administering water resources. With the passage of the Adjudication and Administration Act of 1969, Colorado began to recognize the need to create an institutional environment that manages a developed landscape.

The intent of the act is clear:[284]

> (1) (a) It is hereby declared to be the policy of the state of Colorado that all water in or tributary to natural surface streams, not including nontributary ground water as that term is defined in section 37-90-103, originating in or flowing into this state have always been and are hereby declared to be the property of the public, dedicated to the use of the people of the state, subject to appropriation and use in accordance with sections 5 and 6 of article XVI of the state constitution and this article. As incident thereto, it is the policy of this state to integrate the appropriation, use, and administration of underground water tributary to a stream with the use of surface water in such a way as to maximize the beneficial use of all of the waters of this state.

With the act, Colorado established formal mechanisms for planning water resources management and recognized the shortcomings of the previous Adjudication Act of 1943.

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[283] Hobbs, G. J. (1999). "Colorado's 1969 Adjudication and Administration Act: Settling In." University of Denver Water Law Review 3 U. Denv. Water L. Rev. 1.
[284] 37-92-102 - Legislative declaration - basic tenets of Colorado water law.

One author remarked about the previous act, which bears similarity to California's existing adjudication procedure, "Too little direction, too many districts."[285]

3. Summary of Colorado

The groundwater laws of Colorado are some of the oldest statutory laws governing groundwater in the western United States. The system is exhaustive in its coverage of all aspects of quantity control in groundwater allocation.

With respect to groundwater quality protection, the Department of Public Health and Environment's Water Quality Control Commission has promulgated quite significant regulations that protect present and future groundwater uses. The Commission has set forth in Regulation No. 41 a procedural system for classifying groundwater based upon use.[286] This regulation includes nonpoint land use activities in ambient quality protection and provides for controlling groundwater quality when it will affect surface water quality.

With respect to groundwater allocation, the distribution of authority among the State Engineer, Groundwater Commission, Groundwater Districts, and the Water Courts provides for an exhaustive coverage of groundwater basins. The recognition that most groundwater is tributary to some stream has provided a sufficient mechanism for resolving interrelated surface water and groundwater disputes.

These quality and quantity aspects of Colorado groundwater law make it a significantly centralized system for allocating and protecting groundwater.

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[285] Hobbs, G. J. (1999). "Colorado's 1969 Adjudication and Administration Act: Settling In." University of Denver Water Law Review 3 U. Denv. Water L. Rev. 1.
[286] Water Quality Control Commission (1987). Regulation No. 41: The Basic Standards from Ground Water. Denver, CO: Colorado Department of Public Health and Environment.

C. Nebraska Groundwater Management

1. Background

Article XV of the Constitution of Nebraska outlines the principles of the public interest in water. Sections 4 and 5 declare water to be a public necessity and dedicate all water to the people.[287]

The riparian doctrine was adopted in 1866, when the Nebraska Legislature adopted the common law of England by statute. It was followed by the passage of the 1895 Irrigation Code, known as Aker's Law, which codified the doctrine of prior appropriation in surface water systems. The State Board of Irrigation, Water Power and Drainage was formed by this law to carry out the appropriation doctrine. These duties have passed through several agencies and have resided within the Department of Water Resources since 1957.

As with most states, judicial law preceded statutory laws with respect to groundwater. In the case of Olson v. City of Wahoo, before the Supreme Court of Nebraska,[288] the English Rule of Absolute Ownership was rejected in favor of the American

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[287] Nebraska. Constitution. Article 15
§ 4. Water a public necessity. The necessity of water for domestic use and for irrigation purposes in the State of Nebraska is hereby declared to be a natural want. § 5 Use of water dedicated to people. The use of the water of every natural stream within the State of Nebraska is hereby dedicated to the people of the state for beneficial purposes, subject to the provisions of the following section. § 6. Right to divert unappropriated waters. The right to divert unappropriated waters of every natural stream for beneficial use shall never be denied except when such denial is demanded by the public interest. Priority of appropriation shall give the better right as between those using the water for the same purpose, but when the waters of any natural stream are not sufficient for the use of all those desiring to use the same, those using the water for domestic purposes shall have preference over those claiming it for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes. Provided, no inferior right to the use of the waters of this state shall be acquired by a superior right without just compensation therefor to the inferior user.
[288] *Olson v. City of Wahoo* (1933). 124 Neb. 802; 248 N.W. 304; 1933 Neb. LEXIS 122.

rule. The American rule limits groundwater extraction to that which is reasonable and beneficial for its intended uses.[289]

Until 1957, the legislature passed no laws controlling groundwater. In this first action, the legislature required the registration of irrigation wells, well spacing, and established a system of preferential uses. In 1963 the legislature defined groundwater and required a permit for wells within 16 meters (50 feet) of a natural surface water stream. Very little else changed until the passage of the Groundwater Management Act of 1975.

2. Nebraska Groundwater Management Act of 1975 and L.B. 108 Amendments

a. History, Policy Declaration, and Goals

In 1975, the state legislature built upon the framework of Natural Resource Districts (NRDs) to develop a hierarchical system of groundwater protection and management (see Figure 23).[290] The Act passed responsibilities for groundwater quantity management to these

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[289] Mossman, S. D. (1996). ""Whiskey is for Drinkin' but Water is for Fightin' About': A First-hand Account of Nebraska's Integrated Management of Ground and Surface Water Debate and the Passage of L.B. 108"." Creighton Law Review 30 Creighton L. Rev. 67.

[290] Later renamed the Groundwater Management and Protection Act.

46-601. Ground water; declaration of policy. The Legislature finds, recognizes, and declares that the conservation of ground water and the beneficial use thereof are essential to the future well-being of this state. Complete information as to the occurrence and the use of ground water in the state is essential to the development of a sound ground water policy. The registration of all water wells in this state should be required.

46-656.02. Declaration of intent and purpose.

The Legislature finds that ground water is one of the most valuable natural resources in the state and that an adequate supply of ground water is essential to the general welfare of the citizens of this state and to the present and future development of agriculture in the state. The Legislature recognizes its duty to define broad policy goals concerning the utilization and management of ground water and to ensure local implementation of those goals.

The Legislature further recognizes and declares that the management, protection, and conservation of ground water and the beneficial use thereof are essential to the economic prosperity and future well-being of the state and that the public interest demands procedures for the implementation of management practices to conserve and protect ground water supplies and to prevent the contamination or inefficient or improper use thereof.

The Legislature recognizes the need to provide for orderly management systems in areas where management of ground water is necessary to achieve locally determined ground water management objectives and where available data, evidence, or other information indicates that present or potential ground water conditions, including subirrigation conditions, require the designation of areas with special regulation of development and use.

NRDs, which had been, formed in 1972.[291] Additional responsibilities in the field of groundwater quality protection were later passed to the NRDs. Within NRDs, management and control areas could be established to actively administer groundwater. NRDs were given broad authority to limit extraction and irrigated areas, along with the ability of ordering best management practices to protect groundwater quality.

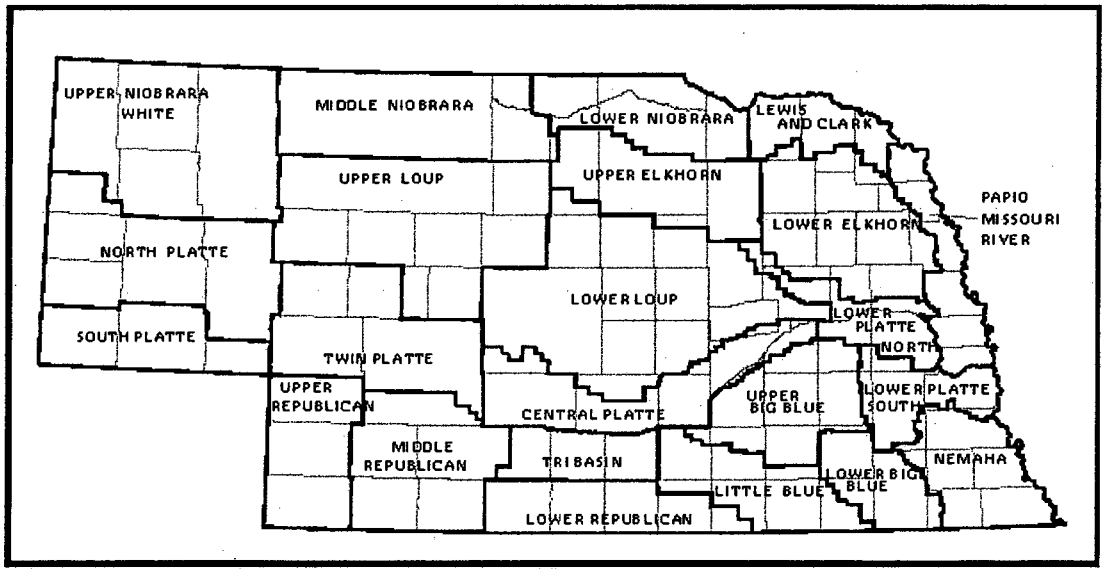

Figure 23: Natural Resource Districts in Nebraska[292]

Recent cases have recognized the state's police powers over groundwater with respect to the Groundwater Management and Protection Act.[293] In a decision concerning the constitutionality of the Act, the Nebraska Supreme Court interpreted state statutes governing groundwater and found that groundwater is owned by the public and that all rights are usufructuary in nature. The case further recognized the right of the state, acting through its administrative agencies, to limit withdrawals in times of shortage as a proper exercise of the state's police power to promote the general welfare.

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[291] Mossman, S. D. (1996). ""Whiskey is for Drinkin' but Water is for Fightin' About': A First-hand Account of Nebraska's Integrated Management of Ground and Surface Water Debate and the Passage of L.B. 108"." Creighton Law Review 30 Creighton L. Rev. 67.

[292] Adapted from the Nebraska Department of Natural Resources.

[293] *Barnford v. Upper Republican Natural Resources District* (1994). 245 Neb. 299; 512 N.W.2d 642; 1994 Neb. LEXIS 54.

Despite these early efforts, a suit brought by Kansas against Nebraska over rights to Republic River water compelled Nebraska to examine the effect of groundwater pumping on surface water. A Water Council was formed in the early 90s to help draft legislation to resolve the dispute. The Natural Resources Committee of the legislature introduced the final bill, L.B. 108, into the 93rd Legislative Session.[294]

b. Actors, Purposes, Powers, and Jurisdiction

New features of L.B. 108 added the authority to interrelate surface water and groundwater to NRDs and DWR. The expanded tools of the NRDs are outlined in §§ 31 to 34 of the bill. The expanded tools of the DWR are covered in §§ 55 to 68. The bill sets out three tracks for the establishment of an "integrated management area," that sets up an institutional environment to concurrently manage groundwater and surface water quantity. The tracks differ dependent on whether a NRD, DWR, or NRD/DWR is to be the manager. NRDs also have the opportunity to co-manage an integrated management area. DWR was given no authority to institute an area except in the Republican River basin until January 1, 1999.

i. NRD Track

If a NRD alone is the manager, a NRD need simply prepare a plan and ask DWR to approve it. If the DWR approves the plan, then the NRD drafts controls to implement the plan and holds a hearing on the plan development and controls. Finally, the NRD designates a management area, and adopts and implements an action plan which can be a joint action plan with the surface water portion developed by the DWR.

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[294] Mossman, S. D. (1996). ""Whiskey is for Drinkin' but Water is for Fightin' About': A First-hand Account of Nebraska's Integrated Management of Ground and Surface Water Debate and the Passage of L.B. 108"." Creighton Law Review 30 Creighton L. Rev. 67.

ii. DWR and DWR/NRD Tracks

The two tracks involving the DWR as manager or co-manager initiate a complicated process.[295] To begin the procedure, DWR must make a preliminary determination that:

> there is a reason to believe that the use of hydrologically connected ground water and surface water resources is contributing to or is in the reasonably foreseeable future likely to contribute to (1) conflicts between ground water users and surface water appropriators, (2) disputes over interstate compacts or decrees, or (3) difficulties fulfilling the provisions of other formal state compacts or agreements . . .

In order for the DWR to begin instituting a study to designate an integrated management area, the Director, in addition to the preliminary conflict determination, must find that "the natural resources district or districts in which such use is located have not designated a management area or have not implemented adequate controls to prevent such disputes or difficulties . . ."

Once a determination of conflict has been made from the integrated management area study, the DWR Director makes a public interest evaluation. To decide whether designating a management area would be in the public interest, NRD or the Director shall consider:

(1) the impacts of the existing or projected diminution or degradation of water resources on:
   a. surface water appropriators;
   b. ground water users;
   c. public health and safety;
   d. social, economic, and environmental values in the affected areas or areas; and
   e. compliance with state laws, rules, or regulations including constitutional and statutory preferences in the use of water and interstate compacts or decrees, and

[295] Mossman, S. D. (1996). ""Whiskey is for Drinkin' but Water is for Fightin' About': A First-hand Account of Nebraska's Integrated Management of Ground and Surface Water Debate and the Passage of L.B. 108"." Creighton Law Review 30 Creighton L. Rev. 67.

(2) whether the designation and implementation of a management area or adoption or implementation of a joint action plan would prevent or alleviate the impact of such diminution or degradation to water resources.[296]

This section also includes the provisions regarding well registration or appropriation dates, and the exemptions of in-stream flow appropriations as surface water appropriators in determining whether conflicts exist.

With the DWR as manager, DWR may designate a management area or require the preparation of an action plan by the NRD. However, certain conditions must exist for the DWR to exercise this power, including:

(1) the quantity of surface water resources must be substantially and adversely impacted because of the use of hydrologically connected groundwater resources,
(2) designating a management area or requiring preparation of an action plan must show the promise of mitigating the disputes over the interstate compact or decree, and
(3) designating a management area or requiring preparation of an action plan must be in the public interest.

In each situation where the DWR is manager or co-manager, the DWR and others conduct a study of the affected area and the DWR prepares a report, followed by a hearing.

The process is more complicated when the DWR submits its report under the DWR track. First, DWR designates a management area or requires an action plan to be prepared by the DWR, the NRD, and any surface water project sponsors. A hearing is held by both DWR and the NRD on the action plan. The NRD can then adopt the groundwater action plan and DWR the surface water plan. If the DWR approves the plan, the NRD implements it. If the DWR does not approve an action plan or if the NRD chooses not to prepare one,

[296] Mossman, S. D. (1996). ""Whiskey is for Drinkin' but Water is for Fightin' About': A First-hand Account of Nebraska's Integrated Management of Ground and Surface Water Debate and the Passage of L.B. 108"." Creighton Law Review 30 Creighton L. Rev. 67.

the decision then goes to the Interrelated Water Review Committee (IRC) for its review. If the Committee believes an NRD action plan should be adopted, DWR is then allowed to adopt and implement its own action plan. If the Committee does not agree to accept the jurisdiction of the DWR, the NRD can implement its own plan if it prepared one.

c. Monitoring, Management, and Decision-making

The Nebraska Natural Resources Commission (NRC) is a state agency with major responsibilities for long range planning, management, and proper utilization of Nebraska's land and water resources. Originally established by the legislature in 1937 as the Soil Conservation Committee, the three-person committee set out to organize the state's soil conservation districts which eventually evolved into Nebraska's 23 NRDs. Programs, responsibilities, and funding have increased many-fold, over 40 staff members now work under a director appointed by the Governor. The director supervises implementation of the various programs of the NRC with considerable emphasis directed toward providing assistance to the state's NRDs. Sixteen commission members help make policy decisions on the allocation of several funds, approve the form and content of planning reports and advise the director on several agency activities. The NRC is currently a functioning unit within the Department of Natural Resources since its merger with the Department of Water Resources.

Thirteen of the members are selected for four-year terms by NRD directors residing in Nebraska's 12 designated river basins. Because of population concentrations, the Missouri tributaries basin, including the Omaha metropolitan area, is represented by two members. The remaining three members are appointed by the Governor, confirmed by the Legislature, and represent three specific resources interests: municipal water users, surface water irrigators, and ground water irrigators.

The DNR has extensive responsibilities in the areas of well registration[297], spacing requirements[298], and the review of NRD management plans.[299] The NRDs have extensive rule-making authority and are responsible for implementing DNR policies.[300] These powers include:

(1) Adopt and promulgate rules and regulations necessary to discharge the administrative duties assigned in the act;

(2) Require such reports from ground water users as may be necessary;

(3) Require meters to be placed on any water wells for the purpose of acquiring water use data;

(4) Conduct investigations and cooperate or contract with agencies of the United States, agencies or political subdivisions of this state, public or private corporations, or any association or individual on any matter relevant to the administration of the act;

(5) Report to and consult with the Department of Environmental Quality on all matters concerning the entry of contamination or contaminating materials into ground water supplies; and

(6) Issue cease and desist orders, to enforce any of the provisions of the act or of orders or permits issued pursuant to the act, to initiate suits to enforce the provisions of orders issued pursuant to the act, and to restrain the construction of illegal water wells or the withdrawal or use of water from illegal water wells.

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[297] 46-651(a) Registration of water wells

[298] 46-651(e) Spacing of water wells; distance.

[299] 46-656.14. Ground water management plan; director; review; duties. The Director of Water Resources shall review any ground water management plan submitted by a district to ensure that the best available studies, data, and information, whether previously existing or newly initiated, were utilized and considered and that such plan is supported by and is a reasonable application of such information. If a management area is proposed and the primary purpose of the proposed management area is protection of water quality, the director shall consult with the Department of Environmental Quality regarding approval or denial of the management plan. The director shall consult with the Conservation and Survey Division of the University of Nebraska, the Nebraska Natural Resources Commission, and such other state or federal agencies the director shall deem necessary when reviewing plans. Within ninety days after receipt of a plan, the director shall transmit his or her specific findings, conclusions, and reasons for approval or disapproval to the district submitting the plan.

[300] 46-656.08. Natural resources district; powers; enumerated.
These powers may be exercised regardless of whether or not any portion of a district has been designated as a management area, in order to administer and enforce the Nebraska Ground Water Management and Protection Act and to effectuate the policy of the state to conserve ground water resources.

The authority which an NRD (or the DNR if an NRD fails to act) has to regulate ground water use is as follows: (1) it may determine the permissible total withdrawal of ground water for each day, month, or year and allocate such withdrawals among the ground water users; (2) it may adopt a system of rotation for use of ground water; (3) it may adopt well-spacing requirements; (4) it may require the installation of well meters; (5) it may adopt a system which requires reduction of irrigated acres; (6) it may require the use of best management practices; (7) it may require the analysis of water or deep soils for fertilizer and chemical content; (8) it may provide certain educational requirements; (9) it may require water quality monitoring and reporting; and (10) other necessary rules.

DNR may also affect surface water by requiring: (1) increased monitoring and enforcement of surface water diversion rates and amounts diverted annually; (2) the prohibition or limitation of additional surface water appropriations; (3) requirements for surface water appropriators to apply or utilize reasonable conservation measures or best management practices consistent with the good husbandry and other requirements of § 46-231; or (4) other reasonable restrictions on surface water use.[301]

NRDs also have extensive authority to control groundwater quality, a situation best illustrated by non-point source nitrate contamination. The law establishes a three-tier system, each tier requiring successively more stringent methods to quell groundwater contamination. The program from the South Platte NRD is described below. Point source

[301] 46-656.28. Joint action plan for integrated management of ground and surface water; preparation; when; procedure; factors; notice; hearing; determination; order; publication; modification; water use monitored; temporary suspension of drilling; variance. (1) If a district on its own motion or following a request by a surface water appropriator, surface water project sponsor, ground water user, the Department of Water Resources, or another state agency has reason to believe that a management area should be designated for integrated management of hydrologically connected ground water and surface water or that controls in a management area should be adopted to include such integrated management, the district may utilize the procedures established in sections 46- 656.19 to 46-656.21or may request that the affected appropriators, the affected surface water project sponsors, and the Department of Water Resources consult with the district and that studies and a hearing be held on the preparation of a joint action plan for the integrated management of hydrologically connected ground water and surface water.

groundwater quality control authority is vested in the Department of Environmental Quality.[302]

Phase I begins when levels of a certain contaminant reach 65 percent of the maximum contaminant level (MCL) for three consecutive years. For nitrogen as nitrate, this is 6.5 PPM. This level requires that: (1) all producers that apply fertilizer or pesticides within the GWMA will be required to become certified in fertilizer and irrigation management practices, and (2) operators will be required to obtain a permit from the NRD before drilling a well.

Phase II begins when levels of a certain contaminant reach 80 percent of the MCL for three consecutive year (8.0 PPM for nitrate nitrogen). This level requires all Phase I actions plus: (1) requires annual 3 foot deep soil sampling, (2) ground water well samples from irrigated fields must be collected and analyzed for the contaminant, (3) operators using manure as fertilizer must conduct nitrogen sampling prior to application, (4) annual reports reflecting the above information must be filed with the NRD, and (5) irrigation wells will be tagged for identification purposes.

Phase III begins when, if after three years in Phase II, contamination levels exceed 95 percent of the Maximum Contaminant Level (MCL) for three consecutive year (9.5 PPM for nitrate nitrogen). This level requires all Phase I and Phase II actions plus: (1) flow meters or other approved water measuring devices are required to measure the amount of water applied to each irrigated field, (2) irrigation scheduling shall be conducted on all irrigated

[302] 46-656.38. Management area; contamination; not point source; Director of Environmental Quality; duties; hearing; notice. If the Director of Environmental Quality determines from the study conducted pursuant to section 46-656.36 that one or more sources of contamination are not point sources and if a management area, a purpose of which is protection of water quality, has been established which includes the affected area, the Director of Environmental Quality shall consider whether to require the district which established the management area to adopt an action plan as provided in sections 46-656.39 to 46-656-43.

fields to assure irrigation efficiency and water conservation, (3) commercial fertilizer applications on all soils before March 1 will be banned for spring-planted crops, (4) spring fertilizer application rates for irrigated crops must be split-applied (preplant and sidedress or through a center pivot chemigation system) or applied with an inhibitor, and (5) a ground water allocation schedule will go into effect.

d. Regional and Long-term Planning

The major instrument of groundwater planning is the Ground Water Management Plan covered in §§ 46-670.011 to 46-673.03. NRDs are required to submit their plans to the DNR for approval. NRD plan contents include:[303]

(1) Ground water supplies within the district including transmissivity, saturated thickness maps, and other ground water reservoir information;
(2) Local recharge characteristics and rates from any sources;
(3) Average annual precipitation and the variations within the district;
(4) Crop water needs within the district;
(5) Current ground water data-collection programs;
(6) Past, present, and potential ground water use within the district;
(7) Ground water quality concerns within the district;
(8) Proposed water conservation and supply augmentation programs for the district;
(9) The availability of supplemental water supplies, including the opportunity for ground water recharge;
(10) The opportunity to integrate and coordinate the use of water from different sources of supply;
(11) Ground water management objectives, including a proposed ground water reservoir life goal for the district. For management plans adopted or revised after July 19, 1996, the ground water management objectives may include any proposed

[303] 46-656.12. Ground water management plan; preparation required; contents; management area designation; when. Each district shall prepare a ground water management plan based upon the best available information and submit such plan to the Director of Water Resources for review and approval.

integrated management objectives for hydrologically connected ground water and surface water supplies;

(12) Existing sub-irrigation uses within the district;

(13) The relative economic value of different uses of ground water proposed or existing within the district; and

(14) The geographic and stratigraphic boundaries of any proposed management area.

3. Summary of Nebraska

Groundwater management in Nebraska is somewhat decentralized and comprehensive. The law is also relatively young, especially the more restrictive L.B. 108 amendments that have increased the interrelation of surface water and groundwater, while also increasing restrictions on nonpoint source groundwater contamination. Nebraska has also passed laws taxing fertilizer, an effort to increase the marginal cost of application.[304] Although there are certain to be legal challenges to full implementation of the law, it remains a significant move towards integrating surface water and groundwater management of quality and quantity.

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[304] Nebraska Fertilizer Taxes: Nebraska State Statutes 77-4401
77-4401. Commercial fertilizer; fee; amount; collection; refund. (1) Through December 31, 1996, there shall be imposed a fee of four dollars per ton upon the gross tonnage of all sales, use, or other consumption in this state of commercial fertilizers, and commencing January 1, 1997, through December 31, 2000, there shall be imposed a fee of one dollar per ton upon such gross tonnage. The fee shall be paid by the purchaser of the commercial fertilizer. Any commercial fertilizer subject to the sales and use tax pursuant to the Nebraska Revenue Act of 1967 shall be exempt from the fee imposed by this section. For purposes of this section, the definitions found in section 81-2,162.02 shall apply.
For an additional law regarding pesticide and fertilizer taxes to protect groundwater, see 1987 Groundwater Protection Act of Iowa.

D. New Mexico Groundwater Management

1. Background[305]

New Mexico's water law is fully based on the prior appropriation doctrine as outlined in the Constitution, Article XVI, § 2, with groundwater specifically mentioned in a groundwater statute in 1927 and 1931, codified in 72-12-1 of the New Mexico Statutes.[306] After some minor modifications, the constitutionality of the 1931 Groundwater Act was upheld by the New Mexico Supreme Court.[307] "Beneficial use is the basis, the measure and the limit to the right to the use of the waters" in the Groundwater Act of 1931.[308]

2. New Mexico Groundwater Management Acts of 1927 and 1931

a. History, Policy Declaration, and Goals

The majority of the state is in declared basins wherein there is an established permit procedure of the State Engineer to grant rights to water. The State Engineer has no

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[305] Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688.
72-1-1. Natural waters; public.
All natural waters flowing in streams and watercourses, whether such be perennial, or torrential, within the limits of the state of New Mexico, belong to the public and are subject to appropriation for beneficial use. A watercourse is hereby defined to be any river, creek, arroyo, canyon, draw or wash, or any other channel having definite banks and bed with visible evidence of the occasional flow of water.
72-12-18. Underground waters declared to be public.
For the purposes of Sections 72-12-18 through 72-12-21 NMSA 1978, all underground waters of the state of New Mexico are hereby declared to be public waters and to belong to the public of the state of New Mexico and to be subject to appropriation for beneficial use. All existing rights to the beneficial use of such waters are hereby recognized.
[306] The water-rights administration responsibilities of the State Engineer are based on three principles found in Article XVI of the 1912 New Mexico Constitution: The unappropriated water of every natural stream, perennial or torrential, within the state of New Mexico, belongs to the public and is subject to appropriation for beneficial use in accordance with the laws of the state. Beneficial use shall be the basis, the measure and the limit of the right to the use of water. Priority of appropriation shall give the better right. Following these fundamental principles, the State Engineer is responsible for the supervision, measurement, appropriation and distribution of the state's water. He performs these duties according to the licenses issued by him and his predecessors and the adjudications of the courts.
[307] *State ex rel. Bliss v. Dority* (1950). 55 N.M. 12; 225 P.2d 1007; 1950 N.M. LEXIS 652.
The Supreme Court held that artesian water and underground reservoir in valley fill overlying such artesian basin, were reserved on or before date Desert Land Act became effective, to state as trustee for public, and were subject to use by public at any time thereafter by authority of state statutes, even though passed after date of patents to land of defendants.
[308] 72-12-2. Right to use waters.

authority in undeclared basins.[309] Some 218,000 square kilometers (84,000 square miles) of the state are in declared basins. In undeclared basins, a party must file suit if one believes his right to water to be infringed, initiating an adjudication procedure similar to California and other western states. In declared basins, objections can be filed against new permits. The State Engineer's authority and discretion as to new withdrawals was upheld most notably in Reynolds and Berry cases.[310] The burden of proof is on the permit seeker to show that no damage will be incurred to existing permit holders.

The State Engineer has extensive powers in this regard because he can therefore protect the rights of the senior appropriator or require the purchase of existing rights before issuance of a permit. Other powers of the State Engineer include determining beneficial uses, the extent of a appropriation within a groundwater basin, determining rights between groundwater and surface water right holders, and issuing permits for groundwater mining.[311]

City of Albuquerque v. Reynolds is the most important case outlining the authority of the state through the State Engineer (Reynolds) to administer surface water and groundwater collectively.[312] Finding that the underground basin from which the City of Albuquerque desired to draw water was linked to a fully appropriated surface water system, initial applications for a well permit were denied. Albuquerque sued and won in district court on the grounds that the city held pueblo rights and the State Engineer had no jurisdiction to impair those rights.[313] On appeal to the Supreme Court of New Mexico, the

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309 72-12-25

310 *City of Albuquerque v. Reynolds* (1962). 71 N.M. 428; 379 P.2d 73; 1962 N.M. LEXIS 1524.

311 Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688.

312 *City of Albuquerque v. Reynolds* (1962). 71 N.M. 428; 379 P.2d 73; 1962 N.M. LEXIS 1524.

313 Dumars, C. T. (1996). "Changing Interpretations of New Mexico's Constitutional Provisions Allocation Water Resources: Integrated Private Property Rights and Public Values." New Mexico Law Review 26 N.M.L. Rev. 367.

court held that the city's claim to pueblo rights could not be properly addressed by the State Engineer because the claim does not fall within the permit system which the State Engineer administers. The Supreme Court also found that the State Engineer had the ability to interrelate surface water and groundwater in approving an application, requiring applicants to relinquish surface water rights to receive a groundwater permit.

Subsequent to City of Albuquerque v. Reynolds in 1962, well permit applications had to: (1) demonstrate the impact of proposed pumping on local surface waters, (2) acquire surface rights sufficient to offset pumping effects, and (3) pass these rights on to the State Engineer's Office.

Interestingly, in Mathers v. Texaco, the New Mexico Supreme Court allowed Texaco a permit to take water even though it would increase pumping costs to other users in the basin.[314] The court found that increased costs did not impair the right (interesting). Additionally, groundwater mining is allowed at the State Engineer's discretion; several western states prohibit groundwater mining by statute.[315]

Water rights adjudication applies to surface and groundwater, providing a court-based means for quantifying rights. All groundwater and surface water rights must be adjudicated, a process that started in 1907 with enactment of the surface water code and continues today.

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[314] *Mathers v. Texaco* (1966). 77 N.M. 239; 421 P.2d 771; 1966 N.M. LEXIS 2780.

[315] Many western states prohibit groundwater mining, for example: Idaho Code Sec. 42-237a(g) 1980, Mont. Code Ann. Sec. 85-2-506(2)(a) 1979, and Nev Rev. Stat. Sec. 534.110(6) 1979 Smith, Z. A. (1984). "Centralized decisionmaking in the administration of groundwater rights : the experience of Arizona, California and New Mexico and suggestions for the future." Natural resources journal: [641]-688..

b. Actors, Purposes, Powers, and Jurisdiction

Eighty percent of the population of New Mexico lives within a declared groundwater basin that the State Engineer oversees (see Figure 24).[316] In addition to the broad powers administered by the State Engineer, Watermasters can be appointed by a majority petition of the water users of any district in New Mexico. The Watermaster shall have authority to regulate the control of waters in the district to prevent waste, and apportion water.[317] In general, the State Engineer has extreme latitude in determining rights to surface water and groundwater resources.

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[316] 72-2-9. Supervising apportionment of waters.
The state engineer shall have the supervision of the apportionment of water in this state according to the licenses issued by him and his predecessors and the adjudications of the courts.

[317] 72-3-2. (District water masters; appointment; removal; duties.) The state engineer shall upon the written application of a majority of the water users of any district in this state, appoint a water master for such district in the state, who may, for cause, be removed by the state engineer, and shall be removed upon a petition of a majority of the water users of said district. The water master shall have immediate charge of the apportionment of waters in his district under the general supervision of the state engineer, and he shall so appropriate, regulate and control the waters of the district as will prevent waste. The state engineer may, if in his opinion the public safety or interests of water users in any district in the state require it, appoint such water master for temporary or permanent service in such district, in the absence of the application above provided for in this article.
72-3-1. Water districts; creation; change; subdistricts.
The state engineer shall, from time to time, as may be necessary for the economical and satisfactory apportionment of water, divide the state in conformity with the drainage areas into water districts to be designated by names, and to comprise as far as possible one or more distinct stream systems in each district. Districts may be changed from time to time as may, in his opinion, be necessary for the economical and satisfactory apportionment of water. Provided, that the state engineer may, when in his opinion it shall be for the best interests of the state and the owners of water rights upon any stream system within the state of New Mexico, divide said stream system into subdistricts, each of which said subdistricts shall be designated by a distinct name.

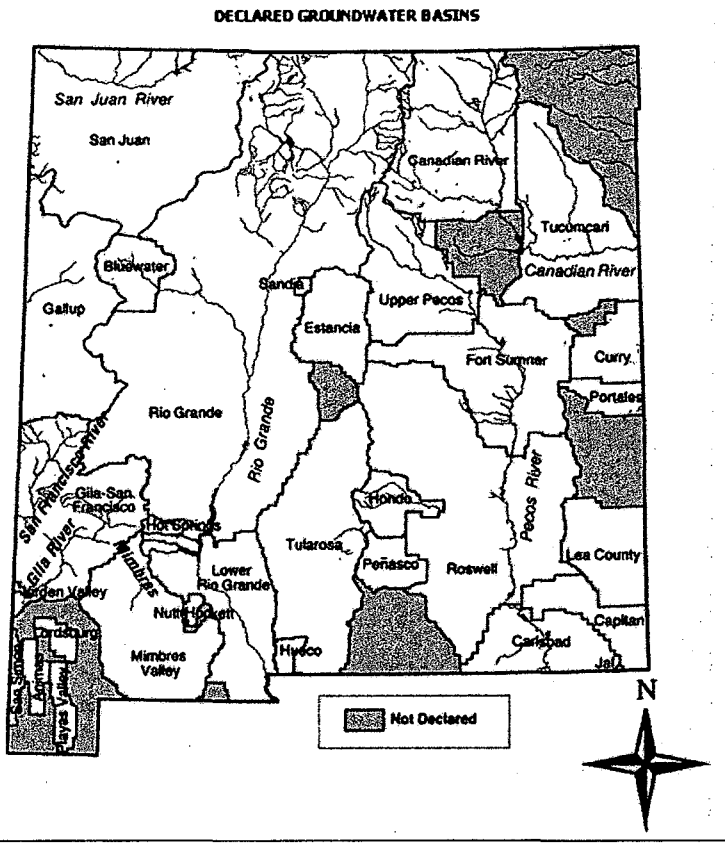

Figure 24: Declared Groundwater Basins in New Mexico[318]

c. Monitoring, Management, and Decision-making

Two major processes affect groundwater management in New Mexico; these are the statutory water rights adjudication process and the administration of groundwater.

i. Water Rights Adjudication

New Mexico law requires the adjudication of all water rights in the state in order to legally define the water right and to gain information needed to maintain a balance between water supply and demand. Water rights have been adjudicated since the enactment of the state surface water code in 1907 and the process is still ongoing. There are 11 basic steps:

(1) The Office of the State Engineer (OSE) or judge orders a hydrographic survey of a stream system or groundwater basin;

[318] Adapted from the New Mexico State Engineer's Office.

(2) OSE staff review water rights records, obtain ortho-rectified imagery, analyze water uses and verify land ownership records;

(3) OSE staff field check all water uses and produce maps;

(4) Data are compiled into a report and sent to legal staff;

(5) Lawsuit is filed by the state, federal government, or interested person;

(6) All water right owners joined in the suit

(7) Offer of judgment is sent to each water right holder and the holder can accept or reject offer;

(8) After resolution, the court confirms agreements reached;

(9) Water right owners have an opportunity to challenge the water rights of others;

(10) Hearings are held to resolve challenges; and

(11) Judge issues a final decree defining all water rights in the adjudicated area.

State Engineer is required to conduct hydrographic surveys of each stream system in the state. This information collection process is a vital part of the adjudication process and would prove a useful tool for California adjudications as well. Throughout the survey process, data are collected to assist the court in deciding how much water to allocate to each potential water right holder. Before any fieldwork takes place in a survey, State Engineer Office staff review water right records for the survey area and obtain satellite imagery. Cropping patterns and crop irrigation requirements are computed. Municipal, industrial, stock, and domestic water uses are analyzed. Land ownership is investigated. The investigations produce evidence on the location, amount, and ownership of water rights.

Following this work, the staff conducts a field check of all water uses and draw maps depicting the areas of water use. The maps and other data are compiled into a report that lists all the known uses of water in the survey area. The complete report is then sent to the State Engineer Office legal staff, and the legal phase of the adjudication process begins.

In this part a suit is filed by the State of New Mexico or another interested party to initiate the process. This use of litigation to perform an adjudication is similar to California in many regards. Every water right holder in both the groundwater and surface water systems are joined into the suit. After the suit, a determination letter is sent to each party to the lawsuit from the State Engineer with an offer. In the offer details are provided for what the state has found to be the:

- amount of the water right
- priority date of the right
- place and purpose of water use
- point of water diversion
- source of water
- ownership of the right

The offer can then be accepted or rejected. Despite the time and financial burden of the adjudication process, it offers several benefits. For the individual right holder, the adjudicated right eliminates the uncertainty regarding the validity or quantity of the right. The state also benefits from having an accurate quantification of rights allocated in a given basin and has information to determine the apportionment of water in dry periods.

ii. Groundwater Administration in Declared Basins

Applications to use groundwater in declared basins need to apply to the state engineer.[319] In the application, the applicant must include:

(1) the particular underground stream, channel, artesian basin, reservoir or lake from which water will be appropriated;
(2) the beneficial use to which the water will be applied;
(3) the location of the proposed well;
(4) the name of the owner of the land on which the well will be located;

[319] 72-5-1. Application for permit; rules; surveys, etc.

(5) the amount of water applied for;

(6) the place of the use for which the water is desired; and

(7) if the use is for irrigation, the description of the land to be irrigated and the name of the owner of the land.

Within this framework, the State Engineer has the authority to approve or deny the application. Protests can be filed by any person who believes their water right will be effected by the permit. Parties who believe that the granting of a permit will be contrary to the conservation of water within the state or detrimental to the public welfare of the state also have legal standing to object.

If no objections are filed, the state engineer will issue a permit if there is unappropriated water within the basin and if issuance of the permit will not be detrimental to the public welfare or other rights. If the State Engineer finds this situation not to exist, he may deny the permit without hearing.

d. Regional and Long-term Planning

Regional water planning is carried out largely under the auspices of 72-14-44 and authorizes the IRC to make grants or loans of funds for the purpose of regional water planning.[320] To facilitate the development of regional plans, a general template format has be authored to standardize the format and information contained within the plans. The State Engineer's Office and the IRC will use the regional plans for developing a coherent state water plan. The assessment portion of the plan should at least include:[321]

(1) inventory of quantity and quality of water resources;

(2) population projections and other water resource demands under a range of conditions;

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[320] 3 N.M. Stat. Ann. §72-14-44 (1993 Cum. Sup.) New Mexico Interstate Stream Commission (1994). Regional Water Planning Handbook.

[321] New Mexico Interstate Stream Commission (1994). Regional Water Planning Handbook.

(3) determination of the manner in which water requirements for the projected demands might be met with management and conservation of water supplies available to the region under existing rights, water supplies, interstate agreements, and court decrees.

In order to be eligible for state funding, the plans should also make substantial efforts to involve the public in the planning process. Documentation of the groups represented the number and location of meetings held should be included in the document.

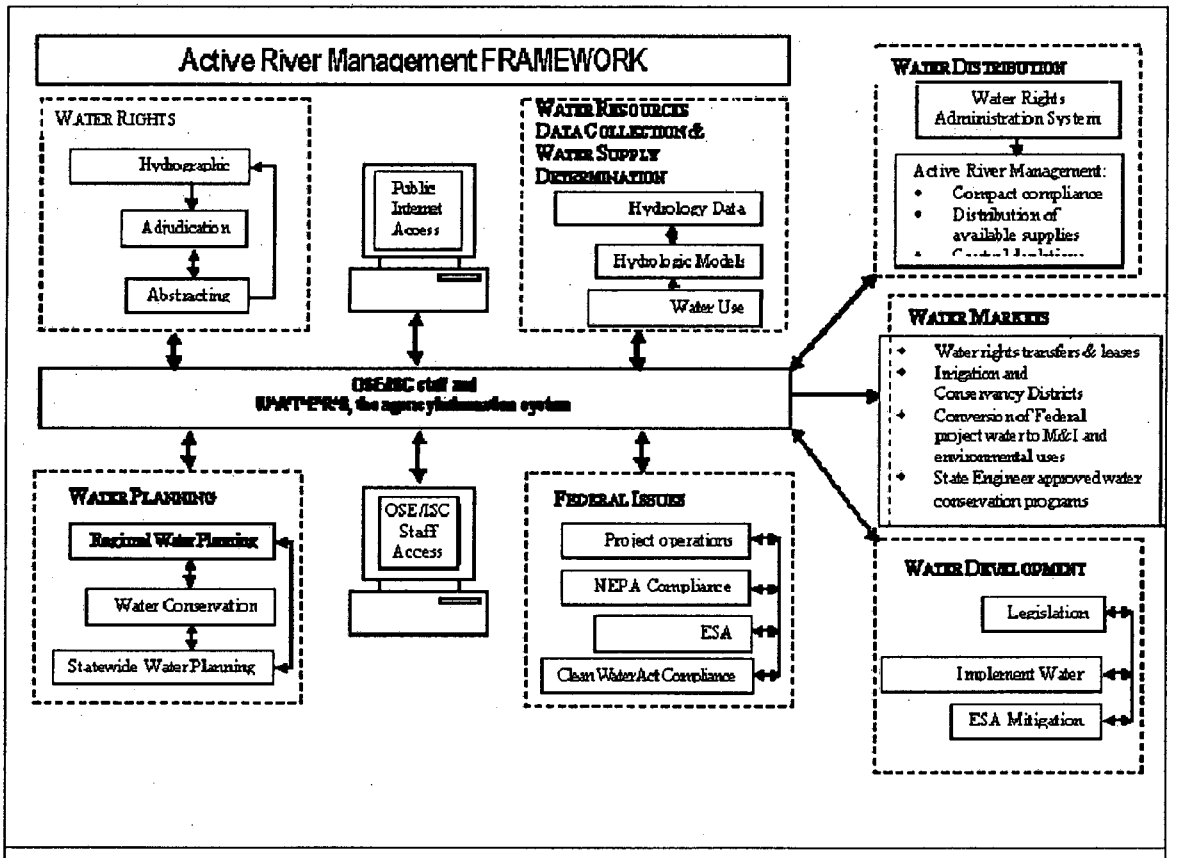

Figure 25: New Mexico's Active River and Resource Management Framework

In addition to locally-initiated water planning, the State Engineer's Office has taken steps to develop a more active approach to managing water in the state, a process they have called Active River Management. Figure 25 shows the conceptual model of the

framework.[322] Interesting aspects of this plan include the organization of resource information including both data about the physical system and water rights. In California, separation of water rights information and data on the resource itself between SWRCB and DWR respectively has hampered the creation of such a system.

3. Summary of New Mexico

Groundwater management in New Mexico is most similar to that of Colorado, with significant authority resting with the State Engineer and an extensive application of the appropriation doctrine. The early creation of groundwater law in 1927 has allowed New Mexico to recognize fewer vested groundwater rights than, for instance, Arizona which has made groundwater apportionment simpler. However, once a permit is issued, it appears as though the State Engineer has a very limited role in active management. Given this limited role, the hydrologic connection between surface water and groundwater needs to be properly assessed at the permitting stage or when adjudications are performed. New Mexico's ambient groundwater quality protection program establishes a system for classifying waters based on anticipated use. Degradation is permitted up to established limits, at which time regulatory measures to limit point and nonpoint pollution take effect.[323]

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[322] Office of the State Engineer and Interstate Stream Commission (2001). White Paper and Strategic Plan: New Mexico's Water Supply and Active Water Resource Management.

[323] State of New Mexico Water Quality Standards
If the existing concentration of any water contaminant in ground water is less than the standard, then degradation of ground water up to the limit of the standard is allowed. If the existing concentration of any water contaminant exceeds the standard than no degradation of the ground water beyond the existing concentration will be allowed.
The State Engineer has defined protectable underground water as all waters in the State of New Mexico containing 10,000 milligrams/liter or less of total dissolved solids (TDS). This does not include any water for which there is no present or reasonably foreseeable beneficial use that would be impaired by contamination. Although not formally defined, the term "reasonably foreseeable" has been taken to mean a time period of not less than 200 years in the future, and in other instances to mean much longer times (thousand of years). The water in lakes and playas should not be contaminated even though they contain more than 10,000 mg/l TDS unless it can be shown that contamination of the lake or playa will not adversely affect ground water hydrologically connected to the lake or playa. The surface waters of all streams within the State of New Mexico, regardless of the quality of the water within any given reach, are designated for protection.

The adjudication process includes a careful collection of data about the groundwater and surface water system in which rights are to be determined. The involvement of the State Engineer in the adjudication allows for experience staff to be involved to a significant degree not found in states with adjudication processes that solely involve the courts. The quantification of all groundwater permits, requirements for extraction monitoring, and the discretion of the State Engineer to determine beneficial uses at the time of permit issuance add clarity to the water rights system. Even with these provisions, New Mexico may face significant water allocation shortfalls in the future given the demands of out of state transfers, Endangered Species Act requirements, and interstate compacts.

E. Texas Groundwater Management

1. Background

The State of Texas holds title to surface water in trust for the public welfare following the decision in Motl v. Boyd, (1926)[324] and more recently asserted in In re Adjudication of Water Rights of the Upper Guadalupe Segment, (1982).[325] Section 11.021 of the Texas Water Code defines the surface water owned by the state to include: the ordinary flow, underflow, and tides of every flowing river, natural stream, lake, and of every bay or arm of the Gulf of Mexico, as well as the storm water, flood water, and rainwater of every river, natural stream, canyon, ravine, depression, and watershed in the state. In short, any channelized flow of water is deemed to be owned by the state.

Texas is one of a few states to observe the English Rule of absolute ownership (Rule of capture), formalized by the court's decision in the case of Houston & T.C. Ry Co. v. East, (1904).[326] This decision followed the ruling in Acton v. Blundell, which found the actions of a well that depleted a neighboring well were *damnum absque injuria* (an injury without remedy). The state does not own the groundwater and thus regulation must contend with the problems of regulating a privately held resource. This is codified in the Texas Water Code and reads "nothing in this code shall be construed as depriving or divesting the owners or their lessees and assigns of the ownership or rights, subject to rules promulgated by a district."[327] Despite the fact that surface waters of the state are public, Pecos County WCID

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[324] *Charles C. Motl v. R. W. Boyd* (1926). 116 Tex. 82; 286 S.W. 458; 1926 Tex. LEXIS 96.
[325] *In Re: The Adjudication of the Water Rights of the Upper Guadalupe Segment of the Guadalupe River Basin* (1982). 642 S.W.2d 438; 1982 Tex. LEXIS 386; 26 Tex. Sup. J. 116.
[326] *Houston and Texas Central Railroad Company v. W. A. East* (1904). 98 Tex. 146, 81 S.W. 279, 1904 Tex. LEXIS 228.
[327] § 36.002. Ownership of Groundwater

No. 1 v. Williams, (1954)[328] held further that impairment of surface water rights through groundwater pumping is also an injury without remedy.[329]

Although groundwater is considered to be a private resource, the government has asserted itself to require the formation of conservation districts to manage groundwater. This authority seems to arise directly from the Texas Constitution, Article XVI, § 59, which states "and the preservation and conservation of all such natural resources of the state are each and all hereby declared public rights and duties; and the Legislature shall pass all such laws as may be appropriate thereto."[330] As with some other states, Texas recognizes the authority to regulate a privately held resource, differentiating between ownership in the sense of property and ownership in the sense of authority to regulate. These Groundwater Conservation Districts are the only authority which can regulate groundwater.

2. Texas Groundwater Management Act and S.B. 1

a. History, Policy Declarations, and Goals

The first major legislative action governing groundwater occurred in 1949 when a petition process for designating underground water reservoirs and creating underground

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[328] 271 S.W. 2d 503

[329] Caroom, D. G. (1999). Texas Groundwater Law: Bickerstaff, heath, Smiley, Pollan, Kever, McDaniel, L.L.P., 2001, http://www.bickerstaff.com/articles/groundwater.htm.

[330] Texas Constitution. Article XVI: § 59. Conservation and development of natural resources; conservation and reclamation districts

(a) The conservation and development of all of the natural resources of this State, including the control, storing, preservation and distribution of its storm and flood waters, the waters of its rivers and streams, for irrigation, power and all other useful purposes, the reclamation and irrigation of its arid, semi-arid and other lands needing irrigation, the reclamation and drainage of its overflowed lands, and other lands needing drainage, the conservation and development of its forests, water and hydro-electric power, the navigation of its inland and coastal waters, and the preservation and conservation of all such natural resources of the State are each and all hereby declared public rights and duties; and the Legislature shall pass all such laws as may be appropriate thereto.

(b) There may be created within the State of Texas, or the State may be divided into, such number of conservation and reclamation districts as may be determined to be essential to the accomplishment of the purposes of this amendment to the constitution, which districts shall be governmental agencies and bodies politic and corporate with such powers of government and with the authority to exercise such rights, privileges and functions concerning the subject matter of this amendment as may be conferred by law.

water conservation districts was authorized.[331] This was expanded in 1955 to allow the Texas Board of Water Engineers to designate such reservoirs on its own accord.

H.B. 2 in 1985 changed underground water reservoirs to management areas, further requiring that groundwater districts be coterminous with management areas. The Texas Water Commission was allowed to consider the use of political boundaries to delineate management areas. A process to determine groundwater areas experiencing critical overdraft was also instituted.

In 1989, S.B. 1212 created the requirement for the Texas Water Commission (TWC) to designate water management areas through an agency rulemaking process. This bill also improved the delineation of responsibility among agencies, instituted timelines and procedures for performing critical area studies, and required groundwater districts to develop comprehensive management plans. In 1991, H.B. 1744 allowed local landowners in designated critical areas to establish underground water conservation districts.

The most substantial modification to Texas groundwater law came through S.B. 1 in 1997. The bill established guidelines for groundwater district comprehensive management plans, requiring conformance with regional water plans. The bill authorized: (1) the Texas Water Development Board (TWDB) to certify management plans met administrative requirements, (2) the State Auditor to determine if districts were implementing the plans, and (3) the Texas Natural Resource Conservation Commission (TNRCC) to ensure district compliance with the plans. It also extended the planning horizon for studying priority groundwater management areas (PGMA) to 25 years.

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[331] H.B. 162, 1949
Texas Natural Resource Conservation Commission and Texas Water Development Board (2001). Priority Groundwater Management Areas and Groundwater Conservation Districts, Report to the 77th Legislature. Austin: State of Texas.

b. Actors, Purposes, Powers, and Jurisdiction

Underground Water Conservation District formation is not obligatory for all parts of the state, currently there are 65 (see Figure 26). District formation can be initiated by the Texas Natural Resource Conservation Commission or on petition from local landowners. UWCDs now encompass most of the densely populated areas of the state.

Formation involves the designation of the geographic region of the underground reservoir and entry of an order that formation would be in the public interest. The TNRCC also meets with the TWDB each year to identify areas of the state which may be experiencing overdraft and can consider whether or not certain areas might require district formation. If the TNRCC finds further that UWCD is in the public interest it can order its creation or annexation to an existing district, or recommend legislation to form the district.

If UWCD formation is initiated by landowners but voters of the effected area reject creation in an area designated as a Priority Groundwater Management Area, the TNRCC must report to the legislature with information on how to best manage water in the area. This can be followed by legislative establishment or state regulation in the area.

Powers of UWCD fall into the broad categories of permitting and rulemaking.[332] Most wells, except those grandfathered at time of district formation and those exempt (private, domestic use, etc) are required to have a permit from the district. Rulemaking can take the form of production limits, spacing requirements, and production fees. Enforcement is quite extensive through suits for injunctive relief and civil penalties.[333]

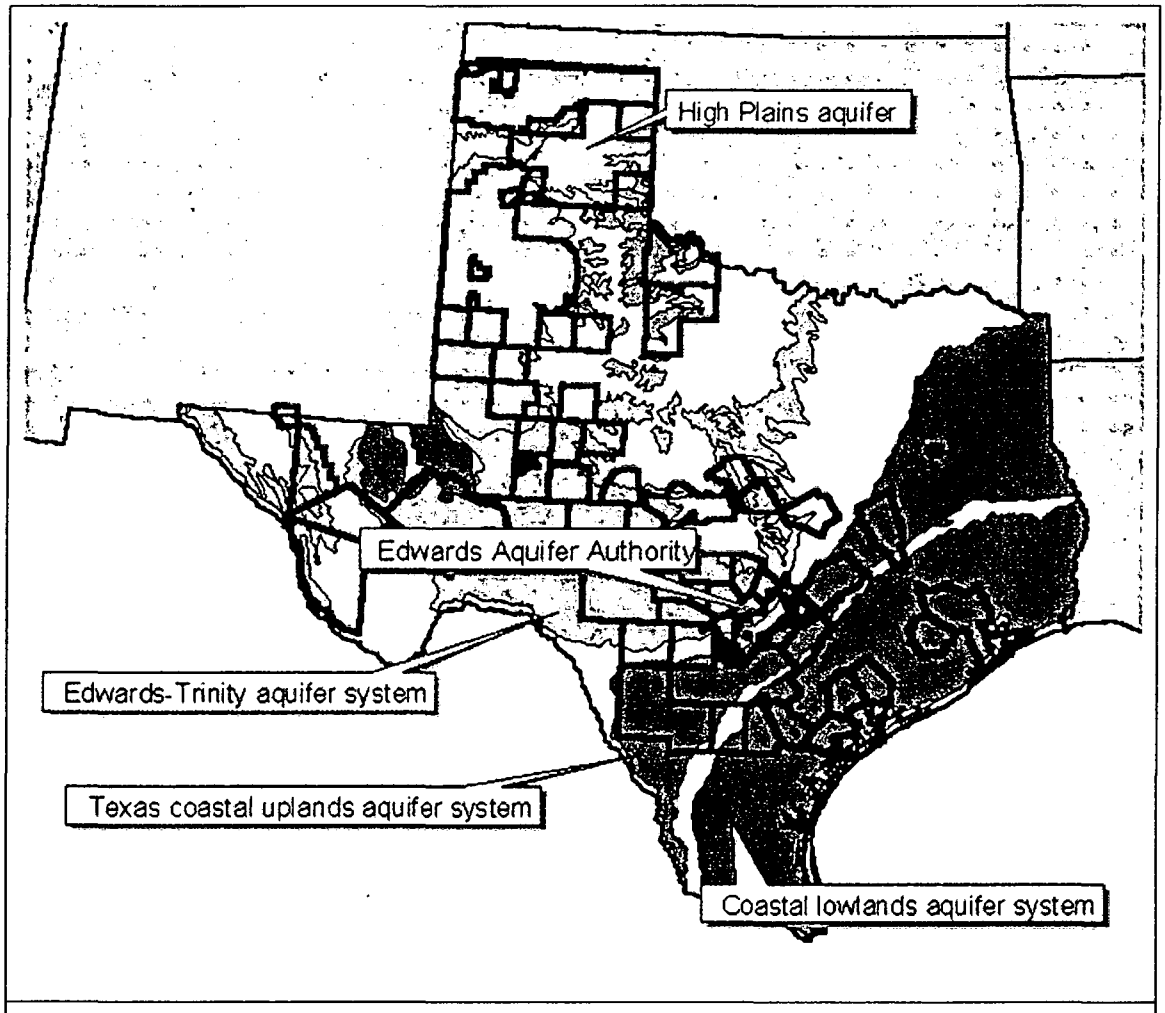

Figure 26: Groundwater Conservation Districts and Major Aquifer Systems in Texas

[332] Texas Water Code § 36.101. Rulemaking Power. (a) A district may make and enforce rules to provide for conserving, preserving, protecting, and recharging of the groundwater or of a groundwater reservoir or its subdivisions in order to control subsidence or prevent waste of groundwater and to carry out the powers and duties provided by this chapter.

[333] Texas Water Code § 36.102. Enforcement of Rules. (a) A district may enforce this chapter and its rules by injunction, mandatory injunction, or other appropriate remedy in a court of competent jurisdiction. (b) The board may set reasonable civil penalties for breach of any rule of the district that shall not exceed the jurisdiction of a justice court as provided by Section 27.031, Government Code.

Districts can also engage in a range of other activities such as data collection, grants, loans, public education, recharge projects, and agricultural conservation. For the most part, districts are financed through property taxes.

The TNRCC oversees districts on a continual basis, in particular so as to assure that they are functioning effectively and that they have adopted a management plan. The state auditor reports the findings of the TNRCC to the state legislature. TNRCC has powers to issue various orders, dissolve the board of directors of the UWCD, remove taxing authority, or dissolve the district altogether. There is also a citizen suit provision which allows "A person who has an estate in land adjacent to the land on which the well is located, or a part that lies within one-half mile of the well, may sue in a court of competent jurisdiction to restrain or enjoin the illegal drilling or operation, or both."[334] As a contrast to the English Rule, the section allows for suits for "Drilling a well without a required permit or operating a well at a higher rate of production than the rate approved for the well is declared to be illegal, wasteful per se, and a nuisance."

Planning requirements are also extensive under the law. Each UWCD must evaluate available supplies, anticipated demands, and create a management plan with goals and objectives. The TWDB must certify the plan and provide it to regional water planning groups for inclusion in the larger water plan of the region.

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[334] § 36.119. Illegal Drilling and Operation of Well; Citizen Suit. (a) Drilling a well without a required permit or operating a well at a higher rate of production than the rate approved for the well is declared to be illegal, wasteful per se, and a nuisance. (b) A person who has an estate in land adjacent to the land on which the well is located, or a part that lies within one-half mile of the well, may sue in a court of competent jurisdiction to restrain or enjoin the illegal drilling or operation, or both. The suit may be brought with or without the joinder of the district. (c) The aggrieved party may also sue for damages for injuries suffered by reason of the illegal operation and for other relief to which they may be entitled. In a suit for damages, the existence or operation of a well in violation of the rules of the district is prima facie evidence of illegal drainage. (d) The suit may be brought in the county where the illegal well is located or in the county where all or part of the affected land is located. (e) The remedies provided by this section are cumulative of other remedies available to the individual or the district. (f) A suit brought under this section shall be advanced for trial and determined as expeditiously as possible. The court shall not grant a postponement or continuance, including a first motion, except for reasons considered imperative by the court.

c. Monitoring, Management, and Decision-making

S.B. 1 amendments greatly enhanced the authority of state agencies to designate priority management areas and create districts. These powers shifted from a passive capability to an active responsibility.

The TWDB, with the TNRCC, has subsequently been authorized to designate groundwater management areas covering all major and minor aquifers in Texas. Groundwater management area designation is aimed at providing the most appropriate jurisdictional boundary for groundwater management. In establishing the groundwater management area, TWDB may include the boundaries of political subdivisions when making its determination but it should be largely based on the geologic properties of the aquifer.

When such an area is designated, the order should also specify how the area should be covered by (1) the creation of one or more new districts or (2) the addition of the land in the priority groundwater management area to one or more existing districts. In an act of deference to the government agency, the designation of a priority groundwater management area may not be appealed nor may it be challenged.

Once the TNRCC has issued its order designating a priority groundwater management area, the landowners in the priority groundwater management area may:[335]

(1) create one or more districts,
(2) have the area annexed to a district that adjoins the area, or
(3) create one or more districts through the legislative process.

If within two years, but no sooner than 120 days, from the date on which the TNRCC issues an order designating a priority groundwater management area, for those areas

[335] §§ 35.008 to 35.012

that are not within a district, the TNRCC is required to create one or more new districts or recommend that the areas, or a portion of the areas, be added to an existing district.

i. Rulemaking Power[336]

A district has broad authority to make and enforce rules in areas such as limiting groundwater production based on tract size or the spacing of wells, to provide for conserving, preserving, protecting, and recharging of the groundwater or of a groundwater reservoir or its subdivisions. These protections can be implemented to control subsidence, prevent degradation of water quality, or prevent waste of groundwater. The statutory recognition of the influence of groundwater use on ambient quality is an important connection absent from groundwater law in California.

ii. Enforcement of Rules[337]

A district may enforce this chapter and its rules by injunction, mandatory injunction, or other appropriate remedy in a court of competent jurisdiction. The TWDB by rule may set reasonable civil penalties for violation of any rule of the district. Complaints may additionally be filed with the court system in the county in which the district's principal office or meeting place is located. The district is entitled to recover all costs of the suit should it prevail in court

iii. Permits for Wells[338]

Districts require permits for the drilling, equipping, or completing of wells. Permit applications must include the following if so requested by the district:

(1) the name and mailing address of the applicant and the owner of the land on which the well will be located;

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[336] § 36.101
[337] § 36.102
[338] § 36.113

(2) if the applicant is other than the owner of the property, documentation establishing the applicable authority to construct and operate a well for the proposed use;

(3) a statement of the nature and purpose of the proposed use and the amount of water to be used for each purpose;

(4) a water conservation plan or a declaration that the applicant will comply with the district's management plan;

(5) the location of each well and the estimated rate at which water will be withdrawn;

(6) a water well closure plan or a declaration that the applicant will comply with well plugging guidelines and report closure to the commission; and

(7) a drought contingency plan.

Before granting or denying a permit, the district shall consider whether:

(1) the application conforms to the requirements prescribed by this chapter and is accompanied by the prescribed fees;

(2) the proposed use of water unreasonably affects existing groundwater and surface water resources or existing permit holders;

(3) the proposed use of water is dedicated to any beneficial use;

(4) the proposed use of water is consistent with the district's certified water management plan;

(5) the applicant has agreed to avoid waste and achieve water conservation; and

(6) the applicant has agreed that reasonable diligence will be used to protect groundwater quality and that the applicant will follow well plugging guidelines at the time of well closure.

Permits are issued subject to district rules to terms and provisions regarding the drilling, equipping, completion, or alteration of wells or pumps. Certain conditions may be required "to prevent waste and achieve water conservation, minimize as far as practicable the

drawdown of the water table or the reduction of artesian pressure, lessen interference between wells, or control and prevent subsidence."[339]

iv. Educational Programming

After the designation of a priority groundwater management area, the Texas Agricultural Extension Service (TAES) is required to initiate an educational program. To accomplish this, TAES may involve the TWDB, the TNRCC, United States Department of Agriculture (USDA), other state agencies, and existing districts. The primary goal of this educational program is to inform the residents of the area's water resources and management options which include the formation of a district. To help guide the educational program, the county commissioners court of each county in the priority groundwater management area can form a committee to assist the TAES in its programming efforts.

d. Regional and Long-term Planning

i. Management Plan[340]

Texas water law has embraced a planning process that seeks to integrate surface water and groundwater planning. It is the responsibility of the district to develop a plan that meets the following criteria:

(1) providing the most efficient use of groundwater;
(2) controlling and preventing waste of groundwater;
(3) controlling and preventing subsidence;
(4) addressing conjunctive surface water management issues;
(5) addressing natural resource issues;
(6) addressing drought conditions; and
(7) addressing conservation.

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[339] § 36.113
[340] § 36.1071

After January 5, 2002, the plan must fully utilize the district's best available data. After completing the plan, the district should forward the plan to the regional water planning group for inclusion in the regional water planning process.

Throughout this process, the TNRCC and the TWDB must provide technical assistance to districts in the development of the management plan. Assistance may take the form of an initial review and comment on the plan in advance of final approval by the TWDB. In the management plan the district must:

(1) identify the performance standards and management objectives under which the district will operate to achieve the management goals;
(2) specify, in as much detail as possible, the actions, procedures, performance, and avoidance that are or may be necessary to effect the plan, including specifications and proposed rules;
(3) include estimates of the following:
    a. the existing total usable amount of groundwater in the district;
    b. the amount of groundwater being used within the district on an annual basis;
    c. the annual amount of recharge, if any, to the groundwater resources within the district and how natural or artificial recharge may be increased; and
    d. the projected water supply and demand for water within the district; and
(4) address water supply needs in a manner that is not in conflict with the appropriate approved regional water plan if a regional water plan has been approved.

Once approved, the district needs to adopt rules to implement the management plan. In developing its management plan, the district is compelled to use groundwater availability modeling information provided by the executive administrator of the TWDB in addition to any available site specific information provided by the district.

ii. Texas Water Development Board Review and Certification of Management Plan[341]

A district shall, not later than two years after the creation of the district to the executive administrator for review and certification. Once a determination that a management plan is administratively complete has been made:

(1) the executive administrator may not revoke the determination that a management plan is administratively complete;
(2) the executive administrator may request additional information from the district if the information is necessary to clarify, modify, or supplement previously submitted material; and
(3) a request for additional information does not render the management plan incomplete.

A management plan takes effect on certification by the executive administrator or, if appealed, on certification by the TWDB. If the executive administrator does not certify the management plan, reasons must be given to the district. The district may then resubmit the plan to the executive administrator. The executive administrator's decision may be appealed to the TWDB. The decision of the TWDB on whether to certify the management plan may not be appealed.

iii. Reporting Requirements[342]

Every two years, the TNRCC in conjunction with the TWDB, must prepare and submit to the governor a report concerning activities during the preceding two years relating to the designation of priority groundwater management areas by the TNRCC and the creation and operation of districts.

The report must include:

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[341] § 36.1072.
[342] § 35.018. Added by Acts 2001, 77th Leg., ch. 966, § 2.28, eff. Sept. 1, 2001

(1) the names and locations of all priority groundwater management areas and districts created or attempted to be created on or after November 5, 1985;
(2) the authority under which each priority groundwater management area and district was proposed for creation;
(3) a detailed analysis of each election held to confirm the creation of a district, including analysis of election results, possible reasons for the success or failure to confirm the creation of a district, and the possibility for future voter approval of districts in areas in which attempts to create districts failed;
(4) a detailed analysis of the activities of each district created, including those districts which are implementing management plans certified under § 36.1072;
(5) a report on audits performed on districts under § 36.302 and remedial actions taken under § 36.303;
(6) recommendations for changes in this chapter and Chapter 36 that will facilitate the creation of priority groundwater management areas and the creation and operation of districts;
(7) a report on educational efforts in newly designated priority groundwater management areas; and
(8) any other information and recommendations that the commission considers relevant.

The TNRCC may also make recommendations for legislative creation or amendment of districts for areas in which current district actions are not meeting stated goals.

iv. Regional Plans

S.B. 1 created 16 regions for regional water planning in the state to contribute to the development of the state water plan (see Figure 27). Within the regional water planning process, regional water planning groups (RWPGs) are charged with the primary duty of assessing water needs and developing conservation, management, and mitigation plans to meet those needs during normal and dry years.[343] The bill also empowers the TWDB to coordinate the regional water planning process and to develop a state water plan the incorporates the findings of the RWPGs. The state plan must address interregional

[343] Texas Water Development Board (2001). Water for Texas: Summary of Regional Water Plans.

conflicts, provide analysis of the water supply and demand situation, and make policy recommendations. The planning effort has been very successful in fostering public participation. TWDB staff attended 596 RWPG meetings.

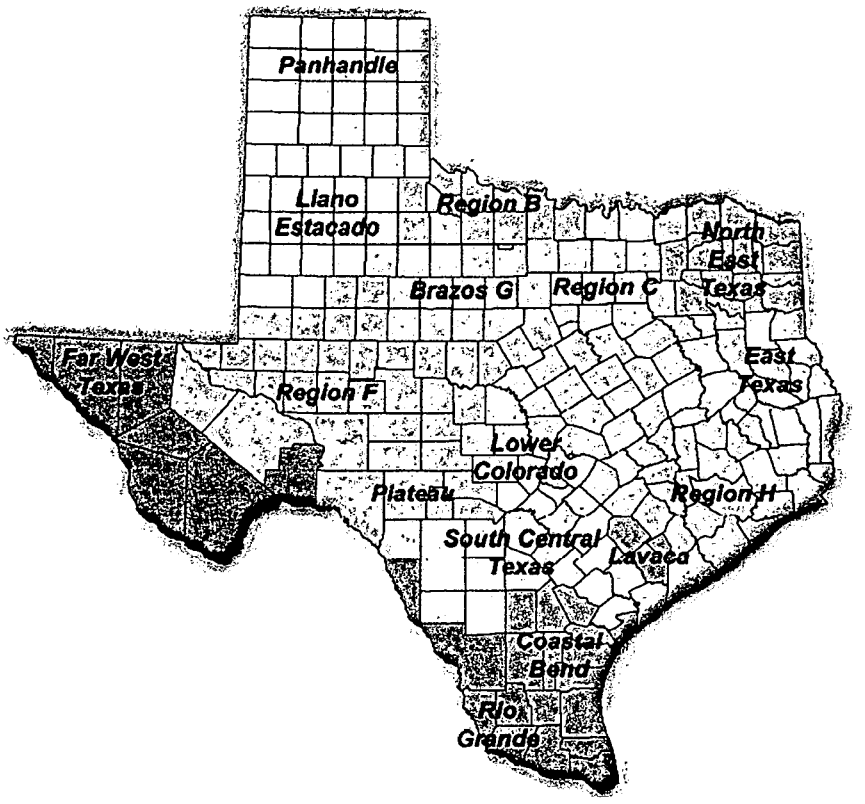

Figure 27: Water planning regions in Texas[344]

3. Summary of Texas

Groundwater law in Texas has been and continues to be largely shaped by the Edwards Aquifer. The Edwards Aquifer supplies municipal and irrigation water to more than 1.5 million Texas residents. It is an example of the cost incurred, both in groundwater overdraft and costly litigation, when legislative involvement is lacking in groundwater policy. It is also an example of the role played by federal law in forming state groundwater policy, in

[344] Texas Water Development Board (2001). Water for Texas: Summary of Regional Water Plans.

this case through the Endangered Species Act. The following timeline highlights the events that led to the creation of the Edwards Aquifer Authority:[345]

- 1959 – The Texas Legislature created the Edwards Underground Water District (EUWD). It was the responsibility of the EUWD to conserve, protect, and increase recharge to the aquifer. In contrast with other districts, the EUWD did not have the authority to limit withdrawals from the aquifer.
- 1987 – The Texas Legislature enhanced the powers of the EUWD to create and enforce a drought management plan.
- 1989 – Concerns over pending pumping restrictions and fees caused two agricultural counties, Uvalde and Medina, to leave the EUWD.
- 1989 – Seeking to have the Edwards Aquifer declared an underground stream and thus subject to state regulation, the Guadalupe-Blanco River Authority filed suit in state district court.
- 1992 – On its own accord, the Texas Water Commission (TWC) found the Edwards Aquifer to be an underground stream and thus subject to state regulation. However, a state district court ruling later invalidated the finding.
- 1993 – In the case of Sierra Club v. Lujan,[346] the Sierra Club brought suit against the USFWS for failing to protect endangered species dependent on the waters of Comal and Marcos Springs. The court held in favor of the Sierra Club and ordered the USFWS to designate minimum spring flows necessary to protect the species. The court also ordered the TWC to develop a plan to ensure that groundwater extraction will not compromise the designated flows in times of drought.
- 1993 – Seeking remedy for numerous disputes, the Texas Legislature enacts S.B. 1477, creating a "conservation and reclamation district" named the Edwards Aquifer Authority. This district is to have substantial rule-making powers in addition to those of the former EUWD. Voting rights concerns and a state district court ruling that the Edwards Aquifer Authority (EAA) Act, on its face constituted an unconstitutional "takings" of private property stall the formation of the Authority.

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[345] Edwards Aquifer Authority (1998). Groundwater Management Plan 1998-2008. San Antonio: Edwards Aquifer Authority.
[346] *Sierra Club v. Manual Lujan* (1993). 1993 U.S. Dist. LEXIS 3361; 36 ERC (BNA) 1533.

- 1996 - On June 28, 1996, the Texas Supreme Court rules unanimously in overturning the district court ruling finding the EAA Act unconstitutional in the case of Barshop v. Medina.[347] The EUWD ceases to exist and the Edwards Aquifer Authority begins operations.

The controversies surrounding the Edwards Aquifer helped the need for administrative governmental intervention in Texas. Challenges from the Endangered Species Act and drought required firm leadership from the state to help resolve disputes. The uncertainty within a groundwater rights system recognizing the English Rule was insufficient to encourage local resolution of disputes. Moreover, protections for endangered species and surface water rights also went unaddressed under the existing institutions of groundwater management.

Among the states examined, Texas is certainly the most unique for blending an old view of the property rights in groundwater, the English Rule, with a very centralized authority of control in the TWDB and TNRCC. Some have argued that Texas should dispose of the English Rule and adopt laws that would transfer the proprietary interest in groundwater to the state, perhaps on state constitutional or public trust grounds.[348] S.B. 1 may have circumvented the need for such policy.

The current management policy after S.B 1 is still taking shape. During the 76th Legislature (1999-2000), 13 new districts were created, bringing the total to 65. Apportioning responsibility among groundwater users to mitigate overdraft and address Endangered Species Act concerns is a challenge. However, the planning, monitoring,

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[347] *Barshop v. Medina County Underground Water Conservation District* (1996). 925 S.W.2d 618; 1996 Tex. LEXIS 81; 39 Tex. Sup. J. 858.

[348] Miles, M. C. C. (1997). "Water Wars: A Discussion of the Edwards Aquifer Water Crisis." South Carolina Environmental Law Journal 6 S.C Envtl. L.J. 213.
Lusk, S. E. H. (1998). "Texas Groundwater: Reconciling the Rule of Capture with Environmental and Community Demands." St. Mary's Law Journal 30 St. Mary's L. J. 305.

reporting, and regulatory aspects of these recent changes seems to present a reasonable way forward. Despite the criticism leveled at Texas's adherence to the rule of capture, S.B.1 shows that such common law traditions are compatible with progressive management to curtail overdraft. More importantly, it shows that quantification of groundwater rights and the apportionment of responsibility are the most necessary parts of groundwater management, perhaps even more important than the underlying common law.

F. Summary of Groundwater Management in Six Western States

Information	California	Arizona	Colorado	Nebraska	New Mexico	Texas
Units of Authority in Groundwater	State Water Resources Control Board, Department of Water Resources	Arizona Department of Water Resources, Active Management Areas, Irrigation Non-Expansion Areas	State Engineer, Ground Water Commission in Designated Basins (Groundwater Management Districts), Water Court	Natural Resource Districts (Management Areas), Department of Natural Resources (a merger of the Natural Resources Commission and the Department of Water Resources)	State Engineer has supreme authority to grant/deny permits in declared basins.	Underground Water Conservation Districts, TNRCC, TWDB
Surface Water Rights	Appropriation and Riparian (also Pueblo Rights)	Appropriation	Appropriation	Appropriation and Riparian	Appropriation	Appropriation and Riparian
Groundwater Rights	Overlying (correlative) and Appropriation	Appropriation	Appropriation (all groundwater is assumed tributary to some stream) and overlying	Overlying and Appropriation	Appropriation	Overlying
Other standards	Reasonable and Beneficial	Reasonable use	Reasonable and Beneficial	Reasonable and Beneficial	Beneficial	English Rule of Capture
Permit to drill a well required?	Yes	Yes	Yes	Yes	Yes	Yes
Permit or court authorization required to pump?	Generally no, (except for certain adjudication basins and statutorily-created groundwater management districts). Tributary groundwater governed by SWRCB via CWC § 1200.	Yes in AMAs and INAs.	Yes, all groundwater assumed tributary requiring permit from OSE. Designated groundwater requires permit from Groundwater Commission.	Yes, all land covered by NRDs that require permits to extract groundwater.	Yes, majority of the state in declared basins, requiring permit from OSE. Prior rights are also being adjudicated.	Yes, in UWCDs.
Interrelation of Groundwater and Surface Water	Adjudication can quantify rights, although future, unexercised, groundwater rights cannot be limited.	AMA planning	All waters are interrelated through the appropriation doctrine. Adjudication and Administration Act of 1969 also links groundwater and surface	L.B. 108 tied groundwater extraction to surface water supplies.	Surface water and groundwater are managed closely by the State Engineer. Adjudication process also interrelates resources in undeclared	Must obtain permit, some are adjudicated (watermasters in some basins), groundwater holds the better right.

			water adjudications.		basins.	
Quantification	Rights are unquantified	Quantified permits in AMAs and INAs.	Quantified permits from OSE or Groundwater Commission for tributary groundwater and designated groundwater.	NRDs issue quantified permits.	Quantified permits issued by OSE.	UWCDs issue quantified permits.
Type of Quantity Management Options Available		ADNR Authority: (1) water rights components of the Code, (2) assured water supply provisions for new developments, (3) underground storage tank and recovery protections, (4) permitting requirements and stipulations, (5) well-spacing requirements, (6) conservation assistance programs, (7) water use reporting requirements, and (8) enforcement authority.	District Authority: (1) To provide for the spacing of wells (2) To acquire lands for the erection of dams and for the purpose of draining lakes, etc (3) To develop comprehensive plans (4) To promulgate reasonable rules and regulations for the purpose of conserving, preserving, protecting, and recharging; (5) To prohibit the use of ground water outside the boundaries of the district ; and (6) To require meters;	NRD Authority: (1) Adopt and promulgate rules and regulations necessary to discharge the administrative duties assigned in the act; (2) Require reports from ground water users; (3) Require meters; (4) Conduct investigations; (5) Report to and consult with the Department of Environmental Quality on all matters concerning the entry of contamination into ground water supplies; and (6) Enforce the Act.	Watermasters, Districts, or OSE Authority: Apportion water, regulate, and control water to prevent waste.	UWCD Authority: monitoring, spacing requirements, production limitations, educational programming, and reporting requirements.
Year of Instatement and relevant laws	AB 3030 1992,	1948, 1980	1965	1975	1907, 1931 Ground Water Ground and Surface Water Protection -- 20NMAC6.2	Enhanced in 1995, 2001

Chapter VI. Strategies for Changing Groundwater Policy in California

We must be prepared to use imaginative new approaches to groundwater management.[349]

A. Discussion

1. The Future Framework

This thesis discusses: (1) the dire state of groundwater in California's SJV and other regions under existing state policy; (2) the origins and extent of governmental authority to control the public resource of groundwater with specific examples from the states of Arizona, Colorado, Nebraska, New Mexico, and Texas; and (3) some approaches that may provide a basis for improving groundwater policy in California. A significant number of legal cases identify this issue as contentious. Any potential actions to manage groundwater bear on the private economic interests of many agricultural and municipal water users.[350] However, evidence shows conclusively that quality and quantity are diminishing under existing management and that some change, likely in the form of legislative action, is necessary.

In addressing these issues, two general observations have been made. First, unsuccessful attempts to protect groundwater quality and quantity in California reflect a growing gap between existing groundwater law and basic groundwater science. This finding applies to stream-aquifer interactions, the relationship between groundwater use and quality, and other issues. Second, managing groundwater effectively requires a higher degree of

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[349] Statement of Ronald Robie, former Director, Department of Water Resources.
Department of Water Resources (1975). Bulletin 118: California's ground water. Sacramento: State of California.

[350] In Texas, Justice Abbott characterized the situation as nothing less than a battle in the case supporting the formation of the Edwards Aquifer Authority. "The clash between the property rights of landowners in the water beneath their land and the right of the State to regulate water for the benefit of all is more than a century old. This case presents another chapter in this ongoing battle *Phip Barshop and The State of Texas et al. v. Medina Country Underground Water Conservation District et al.* (1996). 925 S.W.2d 618; 1996 Tex. LEXIS 81; 39 Tex. Sup. J. 858.."

centralization and hierarchy in arid regions than in temperate climate regimes. The tendency to favor appropriation or overlying rights, often in the form of a quantified permit, over the rule of capture is an example of this centralization. Centralization is further necessitated by the spatial extent of many aquifer systems in the western United States. For example, the Central Valley aquifer system and the High Plains aquifer system span thousands of square kilometers. Actions in these systems are often transmitted a substantial distance through the aquifer and affect other parties. To address these issues, California needs a framework of management that will promote the long-term protection of water resources through coordinated monitoring, planning, and management.

In certain regards, the framework needed today is not unlike that of the great water development projects of the 1930s and 1940s. At that time, federal and state governments recognized their role in exploiting water resources and sought their development. One court in Wyoming stated:

> In the progress of the legislation of this State, respecting the use of water, the significant feature of the changes and additions from time to time has been the principle of centralized public control and regulation.[351]

This form of public control and regulation was necessary to foster the development of resources and assure a minimal level of equity in their distribution. In an open and undeveloped landscape, developing water resources provided value to society. In a developed landscape, the value that groundwater provides to future generations and the resource infrastructure is more clear. In this setting the role of government has shifted.

It remains unclear whether federal intervention or state initiative will prompt the necessary change. Arizona, Nebraska, and Texas only modified groundwater policy when a

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[351] *The Farm Investment Company v. Carpenter et al.* (1900). 9 Wyo. 110; 61 P. 258; 1900 Wyo. LEXIS 8. Wyoming, Potter, Supreme Court of Wyoming,.

federally-funded water project was in jeopardy, when brought to court over the violation of an interstate compact, and due to Endangered Species Act violations, respectively. It is important to recognize that groundwater law is being driven by these forces in the western United States. Increases in population are increasing the demand for the resource in both rural and urban areas. The influence of the Endangered Species Act in the states of Arizona and Texas is forcing the examination of the relationship between in-stream flow and critical habitat. The Clean Water Act, through the TMDL process and nonpoint source pollution (NPS) provisions, is forcing states to examine how groundwater use affects the quality of groundwater and surface water. These and other influences are a significant motivation for state legislatures to undertake reform to groundwater administration that will provide a mechanism to solve these problems.

2. The Costs of Failing to Act

As evidenced by the preceding material, groundwater quality and quantity is a significant problem in many states, particularly in arid regions. In western states, groundwater demand significantly exceeds the supply in many locations, leading to overdraft and subsidence. These problems are paramount in the SJV and Imperial Valley, lands of great agricultural potential that must reckon agricultural productivity with the health of the soil and water systems that support it. Current efforts under local authority to control groundwater extraction and balance supply with surface water deliveries have shown some progress in California,[352] but many regions have chosen not to control groundwater extraction . The limited effort that has been made to balance groundwater extraction with

[352] For an overview of creative strategies in the Santa Clara Valley, see Reynolds, J. L. (2000). Water resources development in Santa Clara Valley, California : insights into the human-hydrologic relationship, University of California, Berkeley: viii, 2, 147.

recharge could face increasing challenges given population growth in the SJV and the absence of regional supply planning.

Although efforts to protect groundwater quantity have taken precedent over water quality issues in California, the long-term degradation of groundwater supplies in many regions from increases in salinity, pesticides, nutrients, and contaminants of industrial origin might present a much more difficult problem to remedy. The costs associated with increases in salinity and other contaminants will cripple municipal water suppliers and agricultural water users.

However, these increased burdens on groundwater resources can be mitigated. Improving supply and quality over longer times requires a planning effort that has been largely absent from agricultural areas and a recognition of the value of groundwater to Californians in the future. The California State Legislature should realize that small communities in the Central Valley rely upon groundwater for domestic needs and will continue to rely upon it for tens if not hundreds of years. This fact was a major motivation for the source assessment and protection component of the federal Safe Drinking Water Act. The costs associated with supplying all of the communities in the SJV with imported surface water vastly exceed the costs associated with reasonable management of the groundwater resource that pervades the SJV.

The SJV's future as a region capable of supporting natural ecosystems has also been overlooked. Several reports from state agencies have suggested fallowing land once the level of salinity makes pursuing agriculture difficult, noting the benefits of returning the land to its natural state. However, the groundwater and soil will be able to support very little with salinity levels in the range of 3,000-10,000 milligrams/liter as are currently present in many

of the areas where land retirement is contemplated.[353] The SJV floor is a natural discharge zone and saline waters kept at bay through intensive drainage practices will undoubtedly migrate upward once the intensive management of the groundwater table ceases.

B. The Institutional Analysis and Development Framework

The Institutional Analysis and Development (IAD) framework is a useful tool for understanding the current crisis in groundwater management and for identifying potential avenues of action. Within the IAD framework, heterogeneities in the physical world, the community, and the legal structures that govern groundwater in California are identifiable. In any given basin in California, vast differences in the (1) the quantity and quality of groundwater, (2) the traditions that shape groundwater use, and (3) the jurisdictional boundaries that dictate groundwater use can be readily seen. The differences among agricultural, domestic, and environmental uses are extensive, resulting in heterogeneities that confound optimal resource utilization.

The findings below identify ways in which governmental institutions, with a limited role currently, might achieve an optimal use of groundwater. Such solutions rely on reducing the heterogeneities currently found in groundwater resource management. The solutions address primarily the areas of (1) the physical system, e.g. the reduction of differences in resource quality and quantity that represent a barrier to management, and (2) the legal system, e.g. the reduction of problems associated with boundaries, information, authority, and incentives. These recommendations and solutions are presented in two parts. The first part discusses an overarching "watershed" or physiographic unit approach for the allocation and protection of groundwater that aims to rectify heterogeneities associated with

[353] San Joaquin Valley Drainage Implementation Program (1998). Drainage Management in the San Joaquin Valley: A Status Report. Sacramento, CA: The Program.

the physical system. The second part discusses the system of governance in groundwater that is necessary to promote optimal use and address the legal heterogeneities therein.

1. The Physical System: Integrating Ground and Surface Water

Over 100 years ago, J.W. Powell's Report on the Lands of the Arid Region of the United States discussed the benefit of drawing political units based on watershed boundaries.[354] Although the report received little attention when authored, the approach taken in the report is being slowly revisited by several states. The evidence presented from several western states clearly links groundwater, surface water, and soil processes together. However, California law still treats these entities quite separately. A similar separation is found in water quality and quantity management.

The watershed approach can be best utilized by creating a forum for management at the watershed scale.[355] This would likely take the form of a district entity that could organize water allocation and protection. This might be realized through Resource Conservation Districts. Resource Conservation Districts are already established in California (see Figure 28). Resource Conservation Districts are generally mutually exclusive and could therefore feed directly into regional planning at larger scales without jurisdictional conflicts. Given that these districts are largely based on hydrologic units, there would also be less conflict in sharing responsibility for nonpoint source pollution that originates in another district.

Although the enabling legislation that created these districts was restricted to programmatic rather than planning or regulatory activities, these entities are locally-based

[354] Powell, J. W. and U.S. Geographical and Geological Survey of the Rocky Mountain Region (1879). Report on the lands of the arid region of the United States : with a more detailed account of the lands of Utah. Washington, D.C.: U.S. Government Printing Office.

[355] For an overview of integrated approaches from managing groundwater and surface water, see Reynolds, J. L. (2000). Water resources development in Santa Clara Valley, California : insights into the human-hydrologic relationship, University of California, Berkeley: viii, 2, 147.

and have boundaries that generally coincide with the boundaries of watersheds of the state. Other states, such as Nebraska, have consolidated various water districts into uniform Resource Conservation Districts. In California, these existing districts are also nested within the SWRCB's regional boards which could promote a higher level of regional planning (see Figure 28).

2. Management: Jurisdiction and Resource Conservation Districts

In utilizing a watershed approach, authority and responsibility needs divided among various stakeholders.[356] Groundwater management responsibilities have been unevenly and unclearly divided among federal, state, and local governments for more than 100 years. No single entity has taken full responsibility, and therefore groundwater management and protection has largely been left to the motivation of local groups. These local interests in many situations lack the capacity (funding, technology, authority) to implement programs that protect a resource that spans local property boundaries. Therefore, this resource must be managed within a hierarchical

system that distributes authority and responsibility among the units of governance most adept at managing it. Several elements of the IAD framework are discussed below, followed by recommendations for overcoming these obstacles.

[356] Malone, L. A. (1990). "The Necessary Interrelationship Between Land Use and Preservation of Groundwater Resources." UCLA Journal of Environmental Law & Policy 9 UCLA J. Envtl. L. & Pol'y 1. Alder, R. W. (1995). "Addressing Barriers to Watershed Protection." Environmental Law 25 Envtl. L. 973.

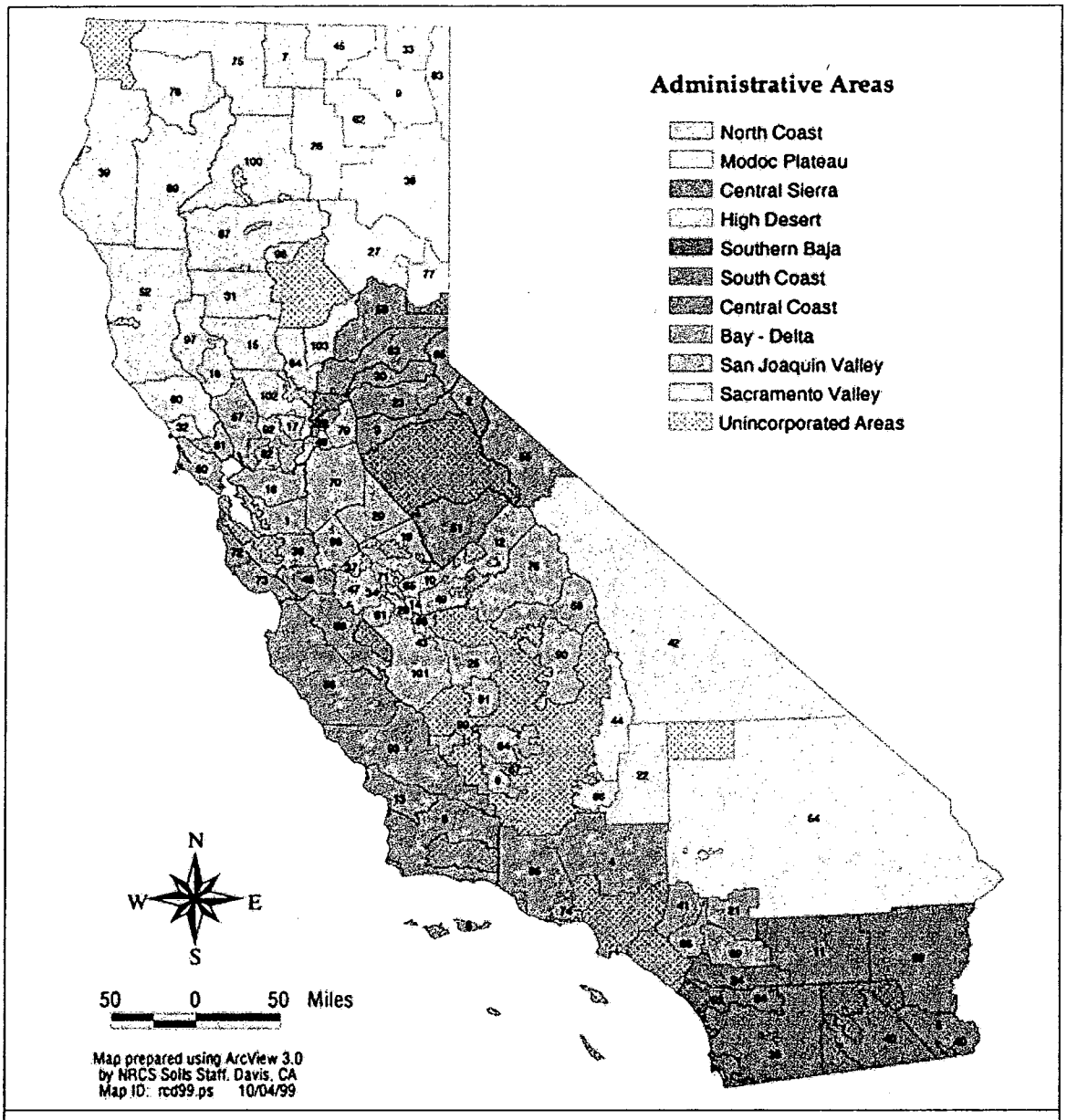

Figure 28: Resource Conservation Districts in California[357]

a. Boundary and Jurisdiction

Groundwater boundaries in California take many forms. The shape of the land surface and geology, coupled with streams and precipitation, helps to define groundwater basins. However, these basins are rarely the units of allocation and protection in California. The boundaries of water districts, counties, and cities(entities with primary authority to

[357] Adapted from USDA.

control and protection groundwater), do not coincide with groundwater basins, even at small scale. Complicating management is that groundwater is interconnected with surface water and soil at large scales. Thus, political boundaries are not organized in such a way as to provide a rational basis for the sustainable management of groundwater.

Several problems can result from such an arrangement. First, the most profound example is the classic externality where the benefits of overdrafting or polluting groundwater accrue to one party whereas the costs are distributed among several stakeholders. Second, situations where the boundaries of water districts overlap may lead to conflicting goals, particularly if one district is formed to allocate water and another is formed to replenish groundwater.

b. Position and Self Interest

Groundwater is used for many different reasons by many different groups throughout California. The position that each use group occupies, such as urban or agricultural, is not homogeneous. Each group has different quality and quantity requirements. Willingness to pay for water of a given quality, even among urban users, varies greatly. Additionally, each of these groups has a different impact on water quality based on the activities undertaken on lands that overlie groundwater basins. Some stakeholders may release contaminants without directly realizing a negative impact from the activity while others may undertake elaborate programs to protect the resource. Given that these contaminants and land use activities are linked to other groups in both spatial and temporal dimensions, systems of decision-making must help to balance the costs and benefits upon each group. However, unclear jurisdictions and boundaries make this impossible.

c. Authority and Scope

Within the federal system of law in the United States, groundwater occupies a peculiar place. The management of groundwater is shared among the federal government, state governments, county governments, municipalities, special water districts, and those with a right to extract groundwater. Few resources are managed in such a way. Although this distribution of authority allows for the resource to be utilized in concert with local and national interests, it has created a complex situation in which to prescribe authority and responsibility for protecting the longevity of the resource.

This situation is most clearly displayed in the conflict that arises between the protection of individual rights to groundwater and the protection of the public interest in groundwater at regional or national levels. Without clear roles for each actor in this federal system of groundwater management, long-term goals are difficult to achieve because each actor fails to understand their relationship to other actors. This situation is made worse by a lack of information exchange to coordinate planning at various scales.

As discussed in Chapter 3, California has a very unclear delegation of statutory authority over groundwater monitoring and management and therefore most disputes must be settled in court. This reliance on the courts has neither allayed uncertainty nor fostered protection of the resource. Management must occur within clearly described roles and responsibilities.

d. Aggregation and Decision-making

In addition to clear jurisdictional boundaries and authority, a transparent decision-making process must exist to synthesize local and regional planning into actions. California's current institutions do not offer opportunities to make binding decisions about groundwater use and protection. Even under AB 3030, plans are not binding and parties objecting to the

plan have little incentive to negotiate or participate . No venues exist to hear disputes over groundwater use and contamination outside of the courts. In situations where the court decides to limit extraction or to reduce groundwater contamination, the successful litigants are often unable to recoup the costs of the court action.[358] In order to protect groundwater, decision-making systems must encourage the resolution of disputes without adversarial court action.

e. Information Exchange and Monitoring

The optimal use of groundwater requires information obtained through a standardized and consistent monitoring effort. Few local entities have the financial resources or expertise to undertake a robust monitoring program, thus some centralized form of technological assistance is necessary. Given the distribution of authority among many actors, information exchange through standardized and routine procedures is important. In California, basic data about the quantity of groundwater pumped is not collected from groundwater users by the DWR. Groundwater quality data is also not shared or coordinated among state governmental agencies. A lack of such information frustrates regional planning and limits the ability of local agencies to act based on all available information.

f. Payoff, Incentives, and Enforcement

Under the current system, different stakeholders have vastly different incentives to protect groundwater. Many have incentives to degrade quality and quantity in return for monetary benefits realized from commercial activities that influence the resource. Notably, this creates another heterogeneity in the use of groundwater. The historical pattern of land

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[358] *United States of America v. State Water Resources Control Board* (1986). 182 Cal.App.3d 82.
City of Barstow v. Mojave Water Agency (2000). 23 Cal. 4th 1224.

allocation, with which comes substantial overlying groundwater rights, is documented to be less than uniform.[359] This non-uniformity in resource distribution also affects the extent to which the resource is optimally utilized in the context of equity. There are direct and indirect connections that transmit the effects of one user's particular incentives to use groundwater upon other users. Given the population and economic activities of California, groundwater demand exceeds supply in the absence of constraints. The weak enforcement of provisions of the water code pertaining to wasteful uses of water[360] and the absence of a administrative procedure to address correlative rights disputes also fosters overdraft.

C. Recommendations

Although Arizona, Colorado, Nebraska, New Mexico, and Texas face many remaining challenges to protect groundwater, each of these states has made significant modifications to groundwater management in the past 50 years. These modifications provide a basis for examining ways in which California groundwater policy might be improved. Issues needing attention in California groundwater are generally categorized as monitoring, regional planning, goal setting, and decision-making.

a. Monitoring

Despite some recent actions of the California State Legislature and the SWRCB to improve the quality of groundwater monitoring in the state, decision-makers are still lacking sufficient information to plan for groundwater use and protection.[361] In particular, activities

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[359] For a discussion of California land and water history with respect to this issue, see Pisani, D. J. (1984). From the family farm to agribusiness : the irrigation crusade in California and the West, 1850-1931. Berkeley: University of California Press..

[360] CWC § 275

[361] For recent efforts in state-wide groundwater monitoring, see State Water Resources Control Board (2000). Plan for Implementing a Comprehensive Program for Monitoring Ambient Surface and Groundwater Quality: State of California.
State Water Resources Control Board and State of California (2001). Proposal for a Comprehensive Ambient Surface Water Quality Monitoring Program. Sacramento: State of California.. AB599, which was signed into

of the DWR, the SWRCB, the Department of Pesticide Regulation, the Department of Health Services, and local water districts should devise a standardized program for sharing information. This is a common practice through USEPA's STORET program. Although this program largely pertains to drinking water quality data, it is also readily applicable to ambient groundwater monitoring. The development of some simple protocols to standardize information collection, in addition to the creation of information systems to collect and store data, would provide a much improved method for understanding trends in quality and quantity through time. There is a need for broader information collection that examines the resource infrastructure, in particular addressing:[362]

(1) the impact of groundwater extractions on surface water availability;
(2) the impact of groundwater use on groundwater, soil, and surface water quality; and
(3) the impact of these activities on ecosystems.

b. Regional Planning and Local Implementation

The task of creating a hierarchical mechanism for regional planning is perhaps the most pressing and challenging for California. The most significant obstacle is the lack of a forum for the coordination of local groundwater management entities at basin levels. Linkages between the regional boards and the districts is not sufficient to coordinate planning,[363] a situation visible through the current TMDL process.[364] A system to link local water districts together within watersheds (or the regional boards' planning units, Figure 29)

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law on October 4th, 2001, creates an interagency task force to determine how groundwater monitoring can be coordinated. However, it does not authorize or provide funding for any monitoring.

[362] Much of this monitoring is required for the SWRCB, DWR, and other agencies to fulfil existing legal requirements, such as CWC §275.

[363] California Regional Water Quality Control Board-Central Valley Region (1998). The Water Quality Control Plan (Basin Plan) for the Californai Regional Water Quality Control Board-Central Valley Region. Sacramento, CA: State Water Resources Control Board.

[364] Regional Water Quality Control Board-Central Valley Region and California Environmental Protection Agency (2002). Total Maximum Daily Load for Salinity and Boron in the Lower San Joaquin River. Sacramento: State of California.

would facilitate the implementation of basin plans and TMDLs. Currently water districts vary extensively in authority, purpose, and physical boundaries, often overlying one another. Unification of these districts into a more general district with wide-ranging authority would provide a necessary link between regional SWRCB objectives and local implementation.

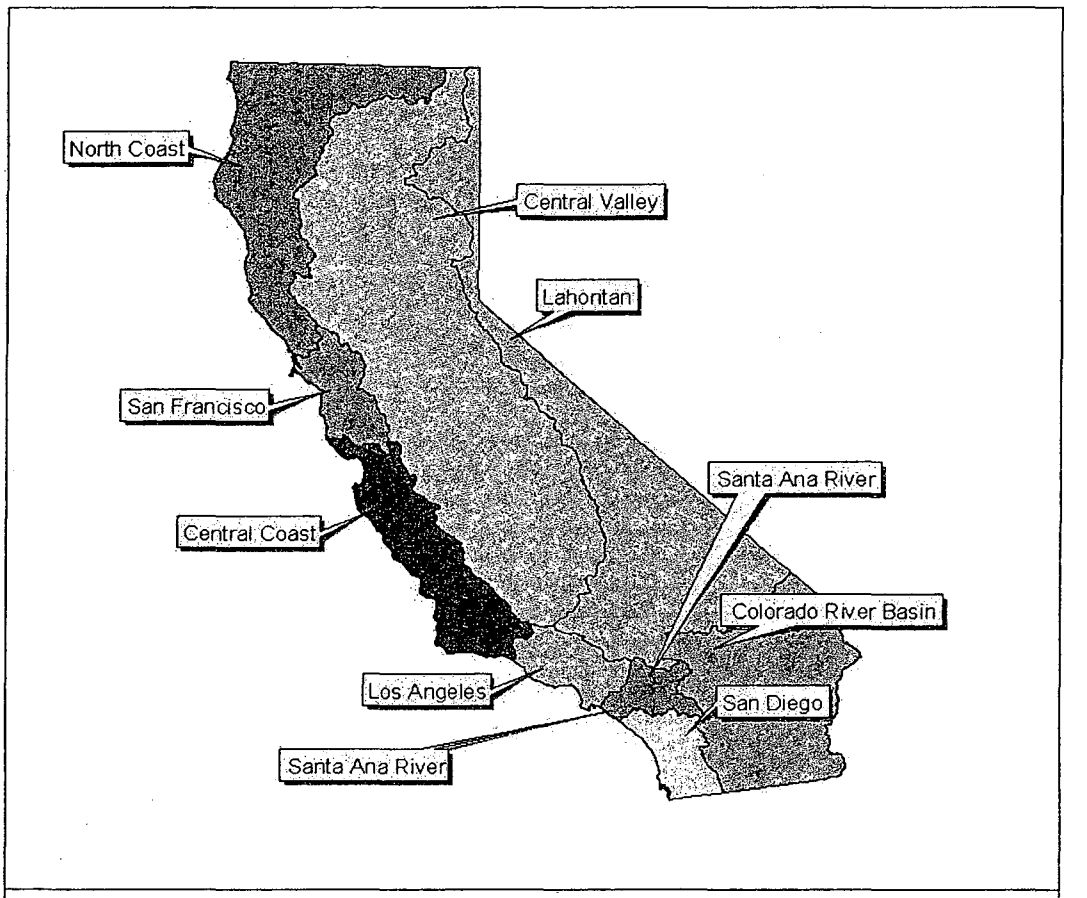

Figure 29: Regional Water Resources Control Boards in California

On several occasions in California's history, consideration has been given to the use of water districts as an active part of water conservations and protection.[365] However, water district creation has continually proceeded on an ad hoc basis, not as the result of a

[365] Lambert, D. A. d. (1984). "District Management for California's Groundwater." Ecology Law Quarterly 11 Eco. L. Quart. 373.
Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.
California Legislature. Assembly Interim Committee on Water (1962). Ground Water Problems in California : A Report of the Assembly Interim Committee on Water to the California Legislature. Sacramento, CA: Assembly of the State of California.

coordinated effort to empower local geographic regions. Through this process, California has amassed no less than 157 district acts. Each creates a separate entity with various powers, boundaries, responsibilities, election rules, and decision-making mechanisms in water management.[366]

Several other states have taken steps to reduce these institutional barriers to regional water management by consolidating districts into more general water management entities. In Nebraska, Natural Resource Districts were the unit chosen for broad management. California currently possesses similar Resource Conservation Districts. These districts were primarily formed for soil and water conservation and engage in wide-ranging activities that include erosion prevention. These types of districts were created nationwide, largely to serve as recipients of funding from the USDA and the National Resource Conservation Service (NRCS).

In California, these districts cover almost all of the state in mutually exclusive areas (see Figure 28). These districts correspond quite well with watershed boundaries and, with increased authority, these districts could provide a powerful framework for more active forms of water and soil conservation. Their unique purposes and coincidence with SWRCB regional boundaries make them quite well suited to the task of long-range planning. Despite the apparent obstacles to such reforms, the existing limitations of the SWRCB in implementing its Basin Plans and TMDL rules could serve as substantial motivation.

c. Goal Setting and Decision-making

Within the resource conservation district framework presented above, quantifiable goals should be set for groundwater quality and quantity management in the ambient

[366] Department of Water Resources (1994). Bulletin 155: General Comparison of Water District Acts. Sacramento: State of California.

environment. These goals are generally present in regional Basin Plans,[367] although the steps for obtaining such goals are not clear. Perhaps the best examples of such programs are found in Nebraska's nitrate control plans. In Nebraska's NRDs, progressively restrictive land use controls are emplaced as nitrate levels in groundwater increase.[368] Additionally, the introduction of a quantified permit system for groundwater extraction is necessary to control overdraft. Arizona's program of Active Management Areas is very firm and clear in its control of groundwater extraction to curb overdraft.

The SWRCB is currently limited in its ability to implement TMDL and other provisions of its Basin Plans given the absence of district ties to local authorities responsible for implementing such plans. This handicap is likely only to grow as population pressures and federal regulations compel the SWRCB to take a more aggressive position. California's Resource Conservation Districts represent a viable, local mechanism for achieving these goals. Existing mechanisms such as AB 3030 and adjudication are not satisfying the need to integrate groundwater protection into broader aspects of surface water and soil protection. Creative, new approaches are needed.

C. Conclusion

California is in a state of transition to a new period of water management. With increasing population, endangered species protections, and ambient water quality protections, California will need to create a system of water governance that is mindful of dynamic, long-term public interests, as well as the constraining attributes of groundwater. Efforts need to be undertaken that link together groundwater, soil, and surface water

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[367] CWC § 13220

[368] See also the 1987 Iowa Groundwater Protection Act. It established a comprehensive policy regarding groundwater contamination and a mechanism to control pesticide and fertilizer contamination via: pesticide manufacturing registration fees, pesticide dealer licensing fees, and fertilizer taxes.

conservation and protection to ensure the long-term viability of domestic water supplies, agricultural productivity, and environmental quality.

These issues are in conflict in many parts of the state such as the SJV, where state institutions that foster long-term protection do not exist. The lack of institutional support has left issues of overdraft, agricultural drainage, and ambient surface water and groundwater concerns unresolved after several decades of debate. The de facto policy has let management efforts depend upon the capacity of local agencies to act, resulting in myriad outcomes and more failures than successes.

California could pursue several paths to remedy the situation as shown by the diversity of approaches found in the five states examined here. However, common characteristics found in many of these states are absent from California. These characteristics include: monitoring, goal setting, regional planning, and integrated management. Although the forms differ, most states have instituted these reforms in recent decades, reflecting a process of learning about natural resources and an active effort on the part of the legislature to bring the legal system into conformance with this learning. Failure to act on the part of legislature at the behest of the head of the State Water Commission in the 1930s,[369] at the urging of the Governor's Commission to Review Water Right's Law,[370] and, more generally, in light of the recommendations of U.S. Senate Subcommittee on Water and Power could well be seen as a tragic oversight.[371] These oversights become increasingly

[369] Holsinger, H. (1939). Review of 'Selected problems in the law of water rights in the West'.
[370] Governor's Commission to Review California Water Rights Law (1978). Final report - Governor's Commission to Review California Water Rights Law. Sacramento, CA: The Commission.
[371] United States. Congress. Senate. Committee on Energy and Natural Resources. Subcommittee on Water and Power (1992). Western Water Policy Review Act of 1991 : hearing before the Subcommittee on Water and Power of the Committee on Energy and Natural Resources, United States Senate, One Hundred Second Congress, first session, on S. 1228 ... September 19, 1991. Washington, D.C.: U.S. Government Printing Office.

embedded in the policy of the state, leading most to seek remedy in the courts, a tactic that has proved insufficient.

In the federal system of governance in groundwater, state government plays an important role. The United States Constitution empowers it with significant responsibilities in allocation and protection. To abdicate this authority today will result in a forgoing of groundwater quality and supply in the future.

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