THE EDWARDS AQUIFER: AN ECONOMIC PERSPECTIVE

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TEXAS A&M UNIVERSITY

MARCH 1993

TR-159

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TECHNICAL REPORT

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The research on which this report is based was financed in part by the Texas Water Resources Institute and The Texas Agricultural Experiment Station.

Technical Report No. 159
Texas Water Resources Institute
The Texas A&M University System
College Station, TX 77843-2118

March 1993

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The Edwards Aquifer: An Economic Perspective

The Edwards Aquifer is of clear importance to Central Texas, and the policy problems presented by this unique resource are very troublesome. The purposes of this short paper are to (1) interpret the management problem, (2) consider the challenges, and (3) propose a basic set of policy responses. To optimize readability, the observations and conclusions of this paper are presented in a condensed form. More detail is available from the published works cited in the endnotes or from the authors.

Issues

- **Water Scarcity is Real**

The Edwards Aquifer has been the most newsworthy water resource issue of the past decade for Texas. Growing use of the Edwards has produced a great deal of conflict and debate. Although the conflict itself is a clear indication of water scarcity, available data can be summarized in ways which highlight the issues more precisely. A useful index is obtained by dividing spring flow by recharge for the period of record. Figure 1 portrays this index averaged over primarily ten-year periods. Although the results obscure both years of plenty and years of drought due to multi-year averaging, the trend is clear. Since 1934, observed spring flow per unit of recharge has fallen about 1% per year. The reason for this decline is growing water withdrawals which, over the same period, have risen from 18% of long run average recharge to 81%.

The Edwards problem is not merely a matter of growing use. A crucial facet of the issue is the newly emerged volatility of aquifer levels and spring flows. Put simply, as a consequence of present water use levels, drought conditions can cause precipitous declines in spring flows and the levels of wells. Figure 2 illustrates this issue using the calculated difference between an index well's annual low elevation and its initial elevation on January 1. The graph exhibits mostly decade averages as in Figure 1. Based on these data, the differences have been growing at about 1/2 foot per year. Aquifer levels (and therefore spring flows) are much more variable during the year than they ever have been before. All uses of the Edwards are at risk when the well water elevations can fall so dramatically.

A third aspect of water scarcity concerns the highly variable recharge of the Edwards. In Figure 3 annual recharge is illustrated in relation to two important quantities: average use during recent years and average recharge. In addition to demonstrating the wide variability of recharge, this graphic indicates the substantial possibility of water shortages under present use patterns. For example, even when spring flows are not considered, 1988-90 water use has exceeded aquifer recharge 47% of the time.

- **The Present Management System is Broke and Needs Fixing**

The current management system is to allow individual groundwater users to take as much water as they want as long as it is personally useful. This *free capture* rule works only when water is not scarce – when water users do not affect each other enough to justify the cost of defining and enforcing true property rights[1] . Now that Edwards Aquifer water has become scarce, it is important to limit water use to available supply and to allocate water to the highest value uses[2]. The current free capture system provides little incentive for people to do either one. There is little incentive to conserve water, because each user bears 100% of conservation costs, but receives only a small portion of the conservation benefits.

Because each user pays only their own pumping costs, there is no penalty for harming other users who must face greater pumping lifts, drill deeper wells, replace pumps, or suffer a water supply loss. The extremely low pumping costs of some users encourages water-intensive production and consumption at the expense of higher value uses. Lately, the possibility that existing usage will be grandfathered by any new management policy has increased the incentive to pump even more water. Not only can current water consumers expand their use without restraint, but new users can commence operations without compensating those whose water use benefits are threatened.

Residual claimants such as spring flow-dependent recreation and natural systems and downstream surface water users receive only what is left over after pumpers have taken what they want at water prices that are too low. That is, water pumping costs understate the regional value of water and therefore lead to overuse. Water is valuable for spring flow and downstream use, but these values are neglected by the current Texas system for managing the Edwards.

Myths Confuse Policy Options

Popular rhetoric concerning the Edwards Aquifer problem often sustains myths or half truths which obstruct progress toward appropriate policy. These misconceptions must be put to rest before any progress can be made towards finding solutions. The four myths listed below are each disputed with a brief argument.

- **Myth #1: Change Will Impose Undue Hardship**

Low value water uses exist here-and-there throughout all sectors, including the residential sector. Most of needed change in water use practices is modest, can be approached gradually, and need only be pursued during drier periods. These changes can be achieved by voluntary efforts if the correct incentives are established. If, however, an economically irrational water policy is chosen for the Edwards, the cost of change will be increased unnecessarily.

- **Myth #2: Pumping Restrictions "Take" Everyone's Property**

There are two sides to every property right. One individual's right is mirrored by another person's obligation toward that right. The public debate has emphasized

only one side of the prevailing free capture rule: that it gives landowners the right to increase their water use beyond current levels.

The often unappreciated side of free capture is that current well owners are not protected from groundwater declines brought about by future increases in water use by others. Every Edwards user has a straw in a glass of water with many other straws in it. Because there is no protection for current users, new or expanding uses are excused from accounting for the costs they impose on others. Net benefits which should be collectively available to well owners are squandered in a "Tragedy of the Commons" scenario[3]. Free capture leads to overuse and forfeits the economic benefits that should be received from the aquifer.

- **Myth #3: New Water Projects Will Save the Day**

Projects to increase water supply can temporarily forestall water shortage, but the economic and environmental costs are high. Moreover, increased use can rapidly nullify the added water supply. At present, water development in the form of concrete and pipe is a dubious solution to water scarcity because the costs of identified projects presently outweigh benefits[4]. We must be mindful that current agricultural and urban water use patterns are a result of low water prices made possible by the unique character of the Edwards. Other water supply alternatives are more costly. Water use practices that are proper for cheap water may need to be modified or discontinued if high-cost surface water is developed. While some new water projects may have economic merit, either now or at a later date, careful appraisal of water development projects is needed to avoid the damages of poor decisions.

- **Myth #4: Water Markets Injure Water Users**

Markets require clearly defined, enforceable property rights. That means the quantification of each user's water rights. If each user's initial water rights are based on past water use, changes in water use practices become voluntary. Current water users benefit because they are protected from additional groundwater mining, and they are free to respond to attractive offers to purchase their water rights.

Two types of water users are potential losers. If water marketing is introduced, water-using landowners who plan to expand water use would have to purchase additional water rights. Depending upon individual circumstances, those costs <u>may</u> outweigh the benefits of more secure title to present water use[5]. A second possible class of losers is landowners who are not currently using any water but who <u>might</u> someday profitably utilize underlying groundwater[6]. Quantification of water rights based on past use would require that these landowners purchase water rights prior to commencing pumping. Of course, failure to limit total pumpage could foreclose these people's option to use groundwater anyway.

The issue is not whether to restrict pumping – it is how to restrict pumping so that the net benefits of Edwards use, across all uses, are large and are distributed fairly.

Challenges

Any modification of existing institutions must recognize the needs of the people of the Edwards region as well as the State. At least four challenges are fundamental in the construction of good water policy for the Edwards.

- **Remaining Competitive**

The region's competitiveness in national and international marketplaces depends upon our ability to marshal resources and use them efficiently. Legal barriers, such as free capture, to using resources in their most valuable uses detract from overall competitiveness and become a growing burden to regional welfare[7]. Moreover, water development commitments that raise water rates have the potential to injure the economic health of the community.

- **Balancing Consumptive Uses and Spring Flows**

Spring flow beneficiaries, lacking another forum for satisfying their water demands, are appealing to the courts. In many ways, litigation can be a crude and expensive resource allocation mechanism. In the future, it may be difficult to modify court-mandated minimum spring flows to respond to changing economic conditions and new technical information. A flexible, nonlitigious mechanism is needed for balancing all the demands upon the aquifer.

- **Preserving Lifestyles and Maintaining Opportunity**

Society is not generally willing to pursue change, even change with positive overall consequences, if it comes at great expense to any one group of people. It is important to be aware of the potential burdens of any policy suggestion. Mitigative measures can be part of the policy package if losses caused by change are concentrated upon one group of people.

- **Living within One's Water Budget**

Farms, families, and factories need to employ appropriate water use and conservation practices, but not all forms of water conservation are attractive. Some conservation measures substitute more valuable resources for water, and some conservation measures sacrifice more profit or consumer satisfaction than the water savings justifies. Incentives that encourage only appropriate conservation are needed. It is difficult to strike such a balance when one considers the varying water preferences of different people and the varying productivity of water in different types of commerce.

City water utilities need to examine innovative ways of signaling water scarcity to their consumers and thereby enlist the will of people to undertake appropriate action. There is little doubt that centrally administered *command and control* conservation mandates impose excessively costly regulations on many users and overlook many cost-effective options individuals could identify regarding their own usage. New policies are needed.

Lessons Learned

Water policy has been changing across the West as well as in Texas. Important lessons, both positive and negative, have been gained from growing experience with different water management policies. Here, we summarize a few recent trends and experiences.

- **In the Rio Grande Valley**

The Lower Rio Grande Valley is among the State's most arid regions. It is also home to the State's most rapidly growing population and economy. Both the aridity and growth of the Valley exceed that of the Edwards region. However, it is the water problems of the Edwards that have captured the State's attention.

Water disputes were once very disruptive for the Valley, but a 1969 court case set the region on a new course[8]. By 1971, water rights were completely quantified, and it became possible to buy and sell water rights as a means to cope with changing demands. In sharp contrast to its pre-1971 water policy, the Valley's surface water market has performed smoothly and successfully. The value of water is well appreciated, and conservation has been stimulated. Water rights have been trading at $500-$600 per acre-foot (for permanent transfers).

Agriculture is still the Valley's dominant water user, responsible for 80-85% of water use, and municipalities have been allowed to grow without being forced to construct expensive water projects. Approximately one-half of the water rights now held by urban utilities and domestic water providers were purchased from agriculture since 1971. In recent years, the importance of water leasing (short term transfers) has increased. Water marketing has played a key role in enabling the Valley's economic growth. Conflict over water resources has been minimal since water markets became the region's dominant water policy.

- **In the West**

The western states have a long record of federally subsidized water development and state and federal rules binding water rights to particular uses and even particular tracts of land. The subsequent pressures of growth, drought, and water scarcity exposed the weaknesses of restrictive water laws. By all accounts, these old regulatory policies have been steadily discarded during the past ten years in favor of transferable water rights[9]. Most laws limiting place and type of use have been eliminated.

Other western trends are noteworthy. Irrigation districts are being allowed to market "salvaged water" conserved by reducing conveyance losses. State proclamations of allowed "beneficial uses" are being expanded to include instream uses so that nondiversionary users can own water and participate in markets. New Mexico's system of marketing groundwater is receiving increased attention because of its careful regard for pumping lift and surface water influences[10]. More recently, federal rules concerning federally developed water are being relaxed to encourage transfer. All of these examples indicate that western states are relying more and

more on water marketing as the means to resolve changing demand and evolving scarcity.

Recommendations

Five recommendations emerge from our considerations of the issues, challenges, and experiences relating to the Edwards problem. The first recommendation is the most fundamental and requires some elaboration.

1. Adjudicate Transferable Groundwater Rights

Management by markets would maximize the productive potential of the Edwards Aquifer and provide the greatest excess of benefits over costs for the region[11]. Preliminary estimates indicate that when contrasted to free capture, water marketing will result in as much as five million dollars of net benefits each year for the region and that this figure will increase over time due to growing demand[12]. Water markets can be initiated by adapting a familiar Texas system – surface water law. Critical elements of this recommendation are to:

- ***Assign pumping limitations*** *to individual well owners on the basis of past use.*

"Adjudication" is the process of establishing property rights to water. Texas has a wealth of recent experience in adjudication because most of the state's river basins were adjudicated over the past 15 years. The general procedure would be for groundwater users to submit documentation of their historical water use to the Texas Water Commission (TWC). Claims can be supported by pumping logs, energy billings, well drillers' reports, crop yield and sales information, etc. After considering the available information within its hearings process, the TWC sets pumping limitations. As part of this procedure, spring flow discharges must also receive licensing in the form of quantified water rights. A State agency such as the Department of Parks and Wildlife could be the designated owner of Edwards water rights devoted to a spring flow portfolio[13].

- ***Employ the seniority system*** *which is already an integral part of surface water law.*

The extreme variability of Edwards recharge calls for a management system that can do more than allocate water under average conditions. The Edwards region needs a means of productively utilizing extra water resources that are available during prolonged high recharge periods. Prolonged low recharge periods require a mechanism for allocating water to only the highest valued water uses.

Assuming water rights are transferable, a fair means of accommodating cyclical water supply is to apply the "first in time, first in right" principle that is codified in Texas surface water law. This principle is simply applied, and it avoids the difficulties which accompany other hierarchical systems for subjectively ranking alternative water uses. If there are water users who, for example, risk large losses during drought cycles, these water users can protect themselves by trading for

senior rights in the marketplace. Minimum-flow spring flow water rights, such as are necessary to support endangered species, could be regarded as highly senior.

- ***Allow transferability*** *of water rights with TWC oversight.*

With transferability, individual users determine what is best for them voluntarily. When all water users can pursue their own interests without imposing costs on others, they maximize the net benefits of the aquifer, thereby enhancing the economic vitality of the region[14]. Together with the seniority system, transferability insures efficient water use during normal and wet periods and achieves a cost-minimizing response to droughts.

Water transfers can be unnecessarily encumbered by state approval requirements. The only legitimate basis for TWC disapproval of a market-based water transfer is the physical impairment of a third party's water rights. Even then the proposed transfer should only be disallowed if the transfer cannot be modified to eliminate the impairment and the third party cannot be compensated by the parties seeking to make the transfer. With a limit on total pumpage and third-party protection, additional TWC transfer approval requirements are unnecessary.

Spring flow users should have access to water markets. If future environmental or recreational values infer a greater value to spring flow water than to another water user, then spring flow user groups should be permitted to contract for water rights on the same basis as any other right holder. Spring flows procured in this manner could be held by the buyer and would augment the base spring flow rights held by the State.

2. Establish an Edwards Watermaster Office (EWO)

The TWC has experience in administering basinwide water rights, and an Edwards Watermaster Office (a branch of the TWC) is needed to enforce water rights, maintain records, and assess water availability. Water right holders should not be allowed to exercise their rights without either (1) having a certified water meter at the well site or (2) having prenotified the EWO of their intended pumping schedule[15]. Officials of the EWO should have convenient access to all well sites, so that compliance can be verified.

An important EWO responsibility will be to make public announcements about which water rights are currently eligible for use based on projected water availability. To simplify this task, it may be desirable to devise a system of 5-10 water right classes. Each class would contain rights of similar seniority, and the class divisions could correspond to hydrologically notable parameters[16].

Another EWO service could be to assist water markets by allowing prospective buyers and sellers to place pertinent information (such as amount and seniority of water) on lists maintained at the EWO.

3. Protect and Nurture Spring Flows

The responsible agency, such as the EWO, should regularly announce eligible water rights classes on the basis of estimated recharge and spring flow impacts. The operational objective should be to permit the maximum possible pumping that is consistent with a high probability of achieving minimum spring flows[17]. To accomplish this task, existing hydrologic models of recharge and aquifer flows will have to be maintained. These models will be employed to predict spring flows under current and probabilistically projected water use/recharge scenarios. Additionally, water right owners should be allowed to use their rights for spring flow augmentation if they so desire.

4. Preserve Rural Opportunity

The economic prosperity of rural communities can be injured by water export to urban areas. To relieve the potential negative consequences of possibly declining agricultural activity, counties could be allowed to place a modest tax on permanent water sales out of the county. Revenues from this tax can be dedicated to economic development efforts – developing commercial infrastructure and attracting industry. The tax rate should be limited (perhaps to 10%) so it does not discourage too many transfers to more valuable uses[18]. For permanent water transfers, it may be advisable for counties to take the tax in the form of water rather than money[19].

5. Send Correct Signals to Urban Water Users

The system outlined above establishes water rights for cities but not for individual users within cities. Water marketing cannot solve the urban problem of encouraging residents to keep total use within a city's water right holdings. Therefore, water market policy must be complemented by urban action. Rather than dictating specific conservation practices, urban water utilities should provide each customer with an incentive to conserve voluntarily. Municipal water customers often face different rates depending upon their usage volumes. Those facing low rates have less incentive to find ways to conserve than do those facing higher rates. This means that a myriad of small conservation actions may be ignored by customers with little to gain from seeking them out. Municipal water utilities can tap this potential for significant conservation benefits for the community at large.

To give each water customer the same incentive to conserve and avoid water waste, the last gallon used by each urban user should cost the same. This can be accomplished fairly through the assignment of baseline usage entitlements by the utility[20]. If water consumption is below the entitlement, the customer receives a proportional credit; if consumption exceeds the entitlement, a proportional surcharge is paid. In this way, all customers are encouraged to conserve water appropriately.

Summary

Business as usual has ceased to be an acceptable system for the Edwards because of the burden it imposes upon regional competitiveness and welfare. Nonrevisionist strategies such as surface water development and spring flow augmentation address symptoms of the problem without curing the cause. Available evidence regarding water development also indicates that these strategies are not cost-effective.

Needed are new policy constructs in tune with heightened water scarcity and the variety of demands now served by the Edwards Aquifer. A system of transferable groundwater rights is commendable for several reasons. It is flexible because it accomodates unforeseeable future shifts in demand. Transferable rights allow voluntary action on behalf of water users as opposed to requiring compliance with offensive regulations. The marketing of water complements regional competitiveness because water is not bound to inefficient uses, and overly expensive methods of water supply enhancement are avoided.

Endnotes

[1]The correct technical term is "Absolute Ownership" (Ronald A. Kaiser., *Handbook of Texas Water Law: Problems and Needs*, Texas Water Resources Institute, Texas A&M University, 1987). Texas once relied on a similar legal doctrine, riparianism, for the management of surface water but later changed to a true property rights system when growing water scarcity indicated that the riparian doctrine had become obsolete.

[2]The notion of resource allocation to highest value uses includes attention to activities that do not involve commodity production and sales such as household consumption and water recreation.

[3]Garrett Hardin. "The Tragedy of the Commons." *Science* 162 (1968): 1243-48.

[4]See, for example, Ronald C. Griffin and Manzoor E. Chowdhury., "Evaluating a Locally Financed Reservoir: The Case of Applewhite," *Journal of Water Resources Planning and Management* (1993): in press; and John D. Merrifield, "A Benefit-Cost Analysis of the Proposed Applewhite Water Supply Reservoir," unpublished, 1989.

[5]For example, although an existing irrigator must incur additional costs to expand irrigation because of need to purchase water rights, already owned water rights will have become more valuable due to their enhanced protection by the State and their prospective value to others.

[6]The potential for harm to prospective groundwater users could be reduced or eliminated by providing compensation, or by using a measure of potential usage, rather than past usage to establish the initial hierarchy of water rights (John D. Merrifield, "Groundwater Resources: The Transition from Capture to Allocation," *Water Resources Research*, in review). Straying from a seniority-based hierarchy risks several complications, however, and confounds the interface with Texas surface water law; see Ronald C. Griffin and Fred O. Boadu, "Water Marketing in Texas: Opportunities for Reform," *Natural Resources Journal* 32 (Spring 1992): 265-88.

[7]Free capture is a barrier because high-value water uses cannot negotiate for additional water, and low-value uses cannot gain by curtailing water use in exchange for money. Free capture locks water resources into uses that are underproductive.

[8]Information for this section is drawn from Chan Chang and Ronald C. Griffin, "Water Marketing as a Reallocative Institution in Texas," *Water Resources Research* 28 (March 1992): 879-90.

[9]See Bonnie C. Saliba and David B. Bush, *Water Markets in Theory and Practice: Market Transfers, Water Values, and Public Policy*, Boulder: Westview Press, 1987; Steven J. Shupe, Gary D. Weatherford, and Elizabeth Checchio, "Western Water Rights: The Era of Reallocation," *Natural Resources Journal* 29 (Spring 1989): 413-34; Larry J. MacDonnell, *The Water Transfer Process as a Management Option for Meeting Changing Water Demands*, USGS Project Report, April 1990.

[10]Jacque L. Emel. "Groundwater Rights: Definition and Transfer." *Natural Resources Journal* 27 (Summer 1987): 653-73.

[11]This argument is more fully developed in Ronald C. Griffin and Fred O. Boadu, "Water Marketing in Texas: Opportunities for Reform," *Natural Resources Journal* 32 (Spring 1992): 265-88.

[12]Bruce A. McCarl et al., *Economic and Hydrologic Implications of Proposed Edwards Aquifer Management Plans*, Technical Report No. 158, Texas Water Resources Institute, March 1993.

[13]We recommend that a portfolio of water rights of varying seniorities be considered for springflow depending on the value and irreversibilities associated with the cessation of springflow. That is, although the value of an aquatic habitat for endangered species may be quite high and might therefore be worthy of extremely senior rights, the amount of water actually needed for this single purpose may be low. The additional water required for water sports need not be afforded the same seniority as that required for species sustenance.

[14]A variety of water market arrangements should be allowed so as to utilize the entrepreneurial motivations of water users. If cities value water more highly during dry periods than do irrigators, short-term leases of water rights can benefit both groups. Alternatively, cities might prefer to purchase water rights and lease them to irrigators during wetter times. A more involved arrangement is for irrigators and cities to negotiate contingency contracts whereby fixed annual payments are made to irrigators in exchange for an agreement to cease irrigation whenever a threshold recharge or aquifer level occurs. Many other agreements may be practical.

[15]The second option may only be appropriate for small wells for which the expense of a meter is unjustified.

[16]For example, Class A, B, and C water rights might be those seniority groupings which would be active if the there was a Moderate possibility that Comal Springs would cease to flow. Classes D and E would not be active under this condition. If the possibility of Comal Springs flow stoppage changes to High, Class C rights would become inactive leaving Classes A and B as the only usable water rights.

[17]The probabilistic character of climate makes is impossible to believe that a particular level of springflow could ever be guaranteed with complete certainty.

[18]Protectionist mechanisms such as our tax proposal involve some sacrifice in aggregate regional welfare and competitiveness as compared to an unencumbered water market. The greater the protection afforded to preexisting economic relationships, the greater the sacrifice, so it is not a good idea to protect "too much."

[19]Such a water tax is compatible with the notion that a region needs to preserve water resources for its future development. Tax revenue is gone once spent, but water rights can be "loaned" to new industry or leased to high bidders if more worthy uses are not immediately available.

[20]Different pricing policies with good efficiency properties are available. One such policy is described in Robert A. Collinge, "Revenue Neutral Water Conservation: Marginal Cost Pricing with Discount Coupons," *Water Resources Research* 28 (March 1992): 617-22. See also Robert A. Collinge, "Transferable Water Rates: The Overlooked Opportunity in Municipal Water Pricing," *Public Finance Quarterly* (1993): in press.

Figure 1. Springflow as a Percentage of Recharge

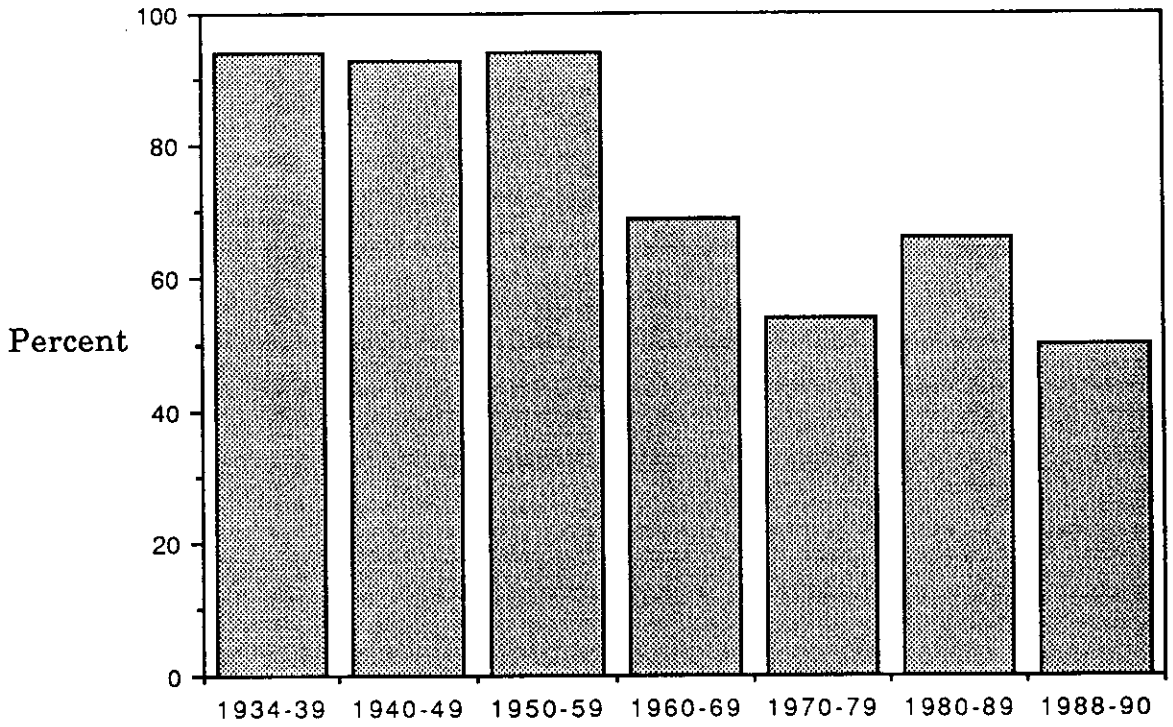
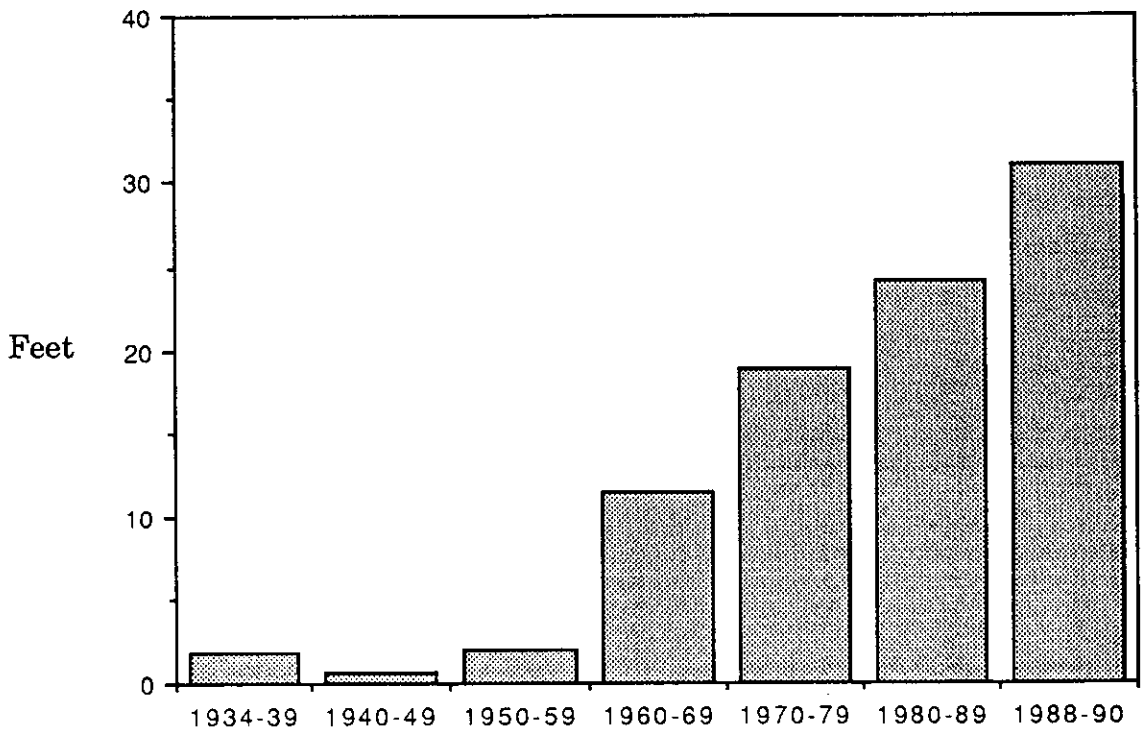


Figure 2. Average Annual Index Well Declines*



*Computed by subtracting each calendar year's lowest index well elevation from the initial elevation at the beginning of the year.

Figure 3. 57-Year Record of Recharge