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CHAPTER IV

INDUSTRY

by

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ABSTRACT

The industrial demand for water cannot be separated from the general growth of population and urbanization in California during the coming decades. Nonetheless, industrial and commercial activities account for more than three-quarters of employment and almost 85 percent of income in the state, and their performance will shape the investment climate and affect economic development and migration.

Although adequate water supply is by no means assured for industry everywhere, its role is ambiguous. On the one hand, the threat to the state's economic climate posed by potential water shortages will require that government and the private sector support measures to maintain an adequate supply, as they have done for many years. On the other hand, the rising cost of new water projects, the competition for state funding in a period of need for reinvestment in urban infrastructure, and the undoubted capacity of industry to outbid, if needed, almost all other users for water, all suggest that industry may best be served by an incremental change toward a partial market approach to water allocation in the medium term future. Such an approach is supported by the fact that most industrial water demand will occur in conjunction with urban and residential development. Competition for future supplies is likely to shape up between agriculture, urban users (including industrial and commercial), and conservation, rather than between industrial users and the rest. Those sectors with especially high demands, for example primary energy, are likely to make their own supply arrangements and seek improved conservation measures in the face of rising costs and local shortages of water.

INDUSTRIAL DEVELOPMENT AND WATER DEMANDS

The creation of new employment and income in private sector manufacturing, transportation, trade, and services will fundamentally shape California's development in the next twenty years. Together, these broad groupings of economic activity account for over 75 percent of total employment and 84 percent of gross income in the state. Their performance establishes the environment of corporate and individual opportunity that determines investment and migration. Although agriculture and government are also critical to the state's economy and management, nonagricultural private and quasi-private sector activities are likely to be the dominant influences on California's future.

Adequate water supply in California is by no means a certainty at all times and places. Therefore, the possibility that insufficient water might affect the economic position of California's leading sectors deserves careful evaluation as the state experiences unemployment problems and threats of worldwide competition for its products. Recently, state government has taken an active role in responding to industrial changes, for example, plant closures, and in planning for the future competitiveness of California's industries. Although water has not been an explicit part of that discussion, the necessity to maintain a "positive economic climate" for investment suggests that any threat to water supplies for industrial growth would be an important concern for development interests in the state and, through them, to state government.

Water's role in industrial development is enigmatic. On the one hand, water is a necessary input for virtually all economic activity and an absolute requirement for some specific industries.[1] Under conditions of extreme shortage, economic activity may be impossible. The amount of water required in industry is in most instances small compared with agriculture or residential use, and its costs are small relative to the cost of labor, raw materials, capital, or marketing. Water is widely available in the quantity and quality suitable for industrial purposes; therefore it is normally not a major consideration in the decision to invest or to locate economic activity in a particular place.

The demand for water for industrial purposes cannot, however, be separated from the larger issue of urban development. There are many arguments about the "chicken-egg" relationship between population growth, especially that due to immigration, and industrial development. It is sufficient to note here that one implies the other, with only rare exceptions. Thus, if we discuss industrial water demand in the broad sense, that is, including the tertiary sectors, we imply a complementary demand for residential uses. Conflicts over water use generally pit urban, agricultural, and conservational interests against each other, rather than focusing on industrial and commercial activities per se.

The following discussion suggests that industrial dependence on water in California is not a particularly worrisome factor in the economic development of the state. Nonetheless, present water policy may not be the best way of serving industrial needs and may actually work against industrial interests if creation of massive, uneconomic water supply facilities imposes heavy subsidy burdens. Since industry and other urban uses can normally outbid agriculture for water supplies, much as a bank can outbid all other uses of urban land, movement toward a partial market approach to water allocation probably represents the wisest course for urban water supply in the medium term future.

PATTERNS OF INDUSTRIAL WATER USE IN CALIFORNIA

In this section of the paper, we examine industrial water use in the aggregate, by sector and by location.

Definitions

Industry is here defined as all nonagricultural economic activity, except for government enterprise, utilities, residences, and municipalities. Thus, it includes mining (Standard Industrial Classification category 10-14), construction (SIC 15-18), manufacturing (SIC 19-39), transportation and communications excluding utilities (SIC 40-49),[2] trade (SIC 50-59), finance, insurance and real estate (SIC 60-69), and services (SIC 70-89). Government (SIC 91-93) is a special category for which we include data but, conventionally, treat separately from the private sector. Time series data on water utilization is difficult to find and subject to definitional problems. In particular, it is not always clear whether water use

information refers to total withdrawals, including water passed back into the sy tem for reuse elsewhere, or to final consumption of water.[3] In addition, it difficult to quantify levels of seriously polluted waste discharge by industrial se tors over time. Thus, the discussion draws eclectically on such data, includi partial series, as exist.

Industrial Water Use in the State

In contrast to its role in generating income and employment, industry us only a small share of water in California. As shown in Table 1, all industri residential, and governmental use in 1976 amounted to less than 6 million acr feet, or about 14 percent of the total. Residential use accounted for at least 8 pe cent, leaving no more than 6 percent devoted to industrial uses. Manufacturin the largest single industrial subsector, accounted for about 2 percent of the state total water use. The remaining 86 percent went to agriculture. While using on 6 percent of the water, however, industry generated 84 percent of gross sta income and 76 percent of total employment. Of the remainder, governme accounted for 12 percent of gross income and 19 percent of employment, a agriculture 3 and 5 percent respectively.

Table 1

California Income, Employment, and Water Use by Sector, 1976

Sector	Gross State Income (Billions)		Employment (Thousands)		Water Use (Thousands of Acre-Feet)	
	Total	Percent	Total	Percent	Total	Percent
Agriculture	5	3	451	5	34,460	86
Mining	2	1	24	0	318	1
Construction	8	7	402	4	12	0
Manufacturing	41	22	1,696	18	950	2
Transportation, communications, and utilities	16	9	489	5	46	0
Wholesale and retail trade	29	16	2,128	23	370	1
Finance, insurance and real estate[a]	27	14	516	6	3,641	9
Services	30	16	1,841	20	41	0
Government	23	12	1,733	19	230	1
Total	181	100[b]	9,282	100	40,064	100

[a]Largely residential water use.
[b]Percentages may not add to 100 owing to rounding.

Source: California Department of Water Resources, *Measuring Economic Impacts*, Bulletin 210 (Sacramento: The Resources Agency, 1980), Table 3, p. 12.

These crude sectoral estimates need to be interpreted with care, especially as regards withdrawals versus final consumption, the linkages between industry and agriculture, and the relationship between industry and urbanization. Nonetheless, the overall picture suggests that conflicts over the industrial use of water are most likely to focus on either (1) institutional difficulties in obtaining agricultural conservation and transferring water from agricultural to industrial/urban use, or (2) problems in developing incremental water supplies for industrial development in areas of the state where such transfers are not technically feasible.

There can be no doubt that if a water market existed in the state, industry would have the capacity to outbid other users. In 1976, for example, the manufacturing sector had about $43,000 in sales per acre-foot of water used. For agriculture, the corresponding figure was $145 in sales per acre-foot, almost 300 times less. No branch of agriculture can compare with any nonagricultural use in value added per unit of water (see Table 3). To ensure supplies, industrial users could pay substantially higher water prices without fundamentally distorting their cost structure.

No use of water, including industrial, is inviolate, of course. Industrial water demand is subject to modification, i.e., is price-elastic and responsive to quantity shortages, and may be altered by changes in processes and behavior due to technological progress or regulation. In fact, the potential for industrial water conservation is substantial. As evidence of adaptation in water demand, it is striking that between 1957 and 1970 the use of water by the manufacturing sector remained constant despite a large increase in total output.[4] Reduction in heavy use sectors offset rising demands in others. However, pollution control efforts rather than shortages or rising costs are likely to be the most important reason for recycling and increased use of reclaimed water across a variety of sectors.

Sectoral Variation in Water Use

Within the broad industrial categories discussed here, there is substantial variation in the absolute amounts of water used and its relative importance as an input to production. Table 2 lists the top nine industrial water using sectors in 1976. This table is unusual in that it includes primary sectors (petroleum extraction), secondary sectors (chemicals), and tertiary sectors (retail) together. Clearly, the way in which sectors are defined will affect their rank. We have chosen to stay at the 2-digit SIC code-level of classification to ensure some degree of comparability.

Retail trade is, somewhat surprisingly, the largest sectoral user of water. This points up an important feature of industrial water use: most is not "process" water, but people-serving, air-conditioning, and landscape-irrigating in purpose. Retail trade uses a large amount of water because it employs very large numbers of people (over 1.6 million person-years in 1976), must provide services for a far greater number, and is highly disaggregated, mainly consisting of very small units, tightly linked to the distribution of population and housing in the state.

With the exception of retail trade, heavy water use in California is concentrated at the primary processing end of the production spectrum. Among manufacturing industries, food processing, with canned and frozen foods the main component within it, is the largest single consumer. Other major manufacturing sector users are paper, petroleum refining, chemicals, lumber and mill products, and stone, clay and glass products. Petroleum and natural gas are the largest users

Table 2

Nine Major Industrial Water-Using Sectors in California, 1976, by Absolute Level of Water Use

Rank	Sector	Water Use (in Acre-Feet)	Percent of Total State Water Use	Percent of Industrial Water Use*
1	Retail trade	358,785	0.9	18.2
2	Food processing	281,763	0.7	14.3
3	Petroleum extraction	185,667	0.5	9.4
4	Paper manufacturing	170,773	0.4	8.7
5	Petroleum refining	141,893	0.4	7.2
6	Chemicals and allied products	75,771	0.2	3.8
7	Lumber and mill products	70,759	0.2	3.6
8	Natural gas and natural gas liquids	60,769	0.2	3.1
9	Stone, clay and glass products	42,824	0.1	2.1
Total Nine Largest Sectors		1,389,004	3.6	70.4

*Total use less agricultural and direct residential.

Source: Adapted from California Department of Water Resources, *Measuring Economic Impacts*, Bulletin 210 (Sacramento: The Resources Agency, 1980), Table 17. Sectors combined to form 3-digit SIC equivalents.

in the primary extractive sectors. If extraction is combined with refinin petroleum processing as a whole exceeds food processing in total water deman Together, these nine sectors account for over 70 percent of all industrial wat used in the state. No single 2-digit sector, however, takes as much as one perce of total water demand in California (see Table 2).

Total water use by sector is, to some degree, misleading since it depen both on the intensity with which the sector uses water in its production process and on the level of output of that sector within the state. One measure of t intensity of water use, value of output per acre-foot of water, is shown in Tab 3.[5] The lower the value of output per acre-foot, the higher the intensity of wat use in the sector, regardless of the scale of production. Where the intensity high, as in agriculture, use will be very sensitive to the cost of water unle demand for the product is highly price-inelastic (an unlikely circumstance for agı cultural products); where intensity is low, as in light manufacturing, a sector likely to be less sensitive to water cost and able to bid up the price in conditio of scarcity.

The striking feature of Table 3 is the great range of value of output p acre-foot of water used across sectors. The difference between the highe (advertising) and the lowest (ricé) is more than six orders of magnitude. Hea manufacturing and extractive industries are typically 10 to 100 times higher in their output-value-to-water-use ratios than agriculture. More important, medium-to-light manufacturing and services, which are the leading edge of industrial growth in the state, are anywhere from 100 to 100,000 times higher in value-to-water-use ratios than agriculture. These are powerful differences. They reinforce the importance to the state of a reliable supply of water for urban-industrial purposes and the potential cost of failure to secure such a supply. They also suggest that transfers of water between sectors, especially out of agriculture, may be an economically efficient response to a condition of tightening and high cost supply.[6]

Location of Industrial Demand

Thus far, the discussion of industrial water use has dealt with the problem at the statewide and sectoral levels only. This does not do justice to the complexity of industrial development and water supply. Industrial water problems are both intensified and mitigated by the uneven locational distribution of demand and supply (see Table 4). The concentration of almost two-thirds the state's population and production in the southern portion of the state means that large absolute quantities of water must be moved from wetter areas to meet current and future demands for urban-industrial water. Neither the Los Angeles basin nor the San Diego area can be self-sufficient at current levels of development. The same is true of the Bay Area. The most intense recent development, in Santa Clara County, has occurred in an area that has previously relied on groundwater and needs to secure a reliable external supplemental supply.

Some of the largest industrial users of water are not, however, located in the major coastal urban areas. A large portion of petroleum and gas extraction is located in the San Joaquin Valley; food processing takes place throughout the Central Valley as well as in the cities; lumber, milling and paper manufacturing are largely concentrated in the northern portion of the state; and mining and quarrying are normally rural activities.

Industrial Water Supply

Presently, industry must secure its water either from (1) public authorities, either special districts or municipal systems, or (2) self-supply under private water rights or municipal systems.[7] Industries that depend on the latter receive water from a handful of public agencies: member units of the Metropolitan Water District of Southern California, the Los Angeles Department of Water and Power, East Bay Municipal Utility District, the City and County of San Francisco, Sacramento Municipal Utility District, Fresno City Water Department, Contra Costa Water Agency, and the municipal water departments of a few other cities.[8] These authorities secure water either by locally developed systems and water rights or via contracts with the state or federal governments. Additional public water supply development is at this stage dominated by state and federal projects, such as the proposed Phase II of the State Water Project and the San Felipe and Auburn units of the Central Valley Project.

Access to existing suppliers and their distribution systems is normally an advantage in industrial locations but can be done without either through self-supply or the creation of new public service districts. Large-scale industry has traditionally not been as dependent on public water supply systems as smaller urban users. Private development of wells and direct extraction from water courses is common. Self-supply in industry is close to 50 percent statewide.[9] Also,

Table 3

Output Value and Water Use in Selected Crops and Industries, 1977

Sector	Value of Output (Millions of Dollars)	Water Use (Thousands of Acre-Feet)	Value of Output per Acre-Foot
General Manufacturing and Services (Light Water Users)			
Finance and insurance	$11,573	4.6	$2,515,870
Communication equipment	4,650	4.9	948,979
Advertising	4,649	0.4	11,647,500
Motor vehicles	4,572	4.6	993,913
Air transportation	4,480	1.5	2,986,666
Textile products	4,177	6.2	673,710
Electronic components	3,781	8.0	472,625
Largest Water Using Industries			
Retail trade	$24,255	358.8	$ 67,600
Petroleum/wells	2,932	185.7	15,788
Wholesale trade	12,214	117.0	104,393
Paper and paperboard	2,848	170.8	16,674
Petroleum refining	11,026	141.9	77,702
Canned and frozed foods	6,951	113.2	61,404
Logging and sawmills	2,046	63.37	32,286
Natural gas	333	60.76	5,480
Sugar	959	41.83	22,871
Industrial chemicals	1,892	37.72	50,159
Stone, clay and quarry	411	26.94	15,256
Cement and concrete	1,135	23.26	48,796
Aircraft	9,081	14.6	621,986
Chemical and mineral mining	145	19.21	7,548
Agriculture (Largest Water Using Crops)			
Hay and pasture	$ 794	11,350	$ 70
Cotton	833	4,677	178
Rice	161	3,521	46
Noncitrus fruits	1,344	3,451	389
Vegetables	1,388	1,972	704
Corn	181	1,691	107
Wheat	229	1,350	170
Sugarbeets	192	1,110	173
Barley	157	1,049	150
Almonds	182	841	193
Citrus	430	820	524
Walnuts	109	646	169

Source: Data drawn from DWR Bulletin 210 (see Table 2); calculations by authors.

for many industrial uses quality requirements are moderate, but it has be estimated that as much as 45 percent of water used in manufacturing is bracki Manufacturers are not averse to use of reclaimed water of adequate quality; t use of internal recirculation systems has risen greatly during the past 20 yea Even where water of very high quality is required, as in electronics, the sm quantities involved in relation to value of product make on-site purification or sp cialized purchases economical for firms.

Table 4

Employment in Major Metropolitan Areas in California, 1979

Standard Metropolitan Statistical Areas	Civilian Employment	Percent of State Total
Los Angeles-Long Beach	3,303,000	32.1
San Diego	682,800	6.6
San Francisco-Oakland	1,507,600	14.6
San Jose (Santa Clara County)	669,900	6.5
Orange County	1,019,300	9.9
Riverside-San Bernardino	533,100	5.4
Sacramento	427,000	4.1
Fresno	243,000	2.3
Total 8 Largest SMSAs	8,385,700	81.5
Total California	10,285,000	100.0

Source: *California Statistical Abstract*, 1979.

Self-supply and treatment is not, however, a viable option for most service activities, which are generaly small in scale and tightly locked into the urban and residential structure. For these sectors, which have been the fastest growing in the state's economy, reliance on municipal water systems is critical. They require stable public supplies of high quality fresh water.

The cost of publicly supplied water to industry depends on several variables, including cost and quality of the input source. By far the largest component of urban supply cost, however, is the expense of building the distribution system. Nationally, the latter makes up roughly one-half of all costs of public water. The expense of delivering in urban areas means that, of necessity, urban users pay more per unit of water than farmers. This difference is typically compounded by price discrimination and subsidy policies of virtually all public agencies from the federal Bureau of Reclamation to local water districts.[10]

An important counterpart to industrial water supply is waste disposal. Resource extraction and heavy manufacturing generate wastewater containing heavy metals, salts and exotic chemicals that are frequently resistant to (and damaging of) conventional treatment systems. This problem cannot be covered within the scope of this paper, but both in cost and technological demands, it may prove to be more difficult than the provision of usable water in the first place. And, as shown by recent discoveries such as the widespread contamination of drinking water wells in the San Gabriel Valley by trichloroethylene, an industrial solvent, failure to solve the pollution problem can worsen the problem of water supply.

FUTURE DEMAND FOR WATER BY INDUSTRY

The future of California's economy is bound up with the development of the U.S. and world economy in which California is now a significant compone Prospects for the U.S. in world markets and in industrial innovation over the co ing years are murky. Recent trends indicate a slowing rate of investment and p ductivity, signs of an aging economy. The key growth sectors of the 20th centu especially the automobile industry, are in disarray, and may have difficulty in st ing more than a partial recovery. It seems unlikely that they can again become dynamic driving forces in the economy that they were. On the other hand, U.S. still holds a narrowing lead in high technology industries, particularly se iconductors and computers, which promise to provide the lead momentum for immediate future. And nascent industries, such as genetic engineering, will c tainly contribute to economic growth if they turn out to have the strength tha predicted. California, on balance, stands to gain absolutely and relatively fr these trends.

Over the past 30 years, the state has evolved from an important but pe pheral part of the U.S. economy, to a national and international leader in ma industrial sectors, notably electronics and advanced technology. The state's tra tional role as an exporter of agricultural products is also likely to continue in future as world demand for food grows. It is unlikely, however, that the decl in the proportion of employment and income generated by agriculture in the st will be reversed. Rather, the vitality of the state's economy will rest upon capacity to maintain investment and innovation in leading industrial sectors, a in its capacity to generate new forms of consumer demand and services.

California has gained population and economic activity from the westw and southward national migration that has continued at varying rates for m than a century. As the state becomes more urbanized and conscious of the ext nal costs of growth, increasing opposition to development and regulation of forms may be expected. The results are likely to be relocation of growth rat than its absolute diminution. In the process, urbanization is likely to continue a rapid pace in the Central Valley and more peripheral parts of the Southern Calif nia metropolitan areas. Elsewhere, growth will not stop, and it will require effective water policy. Projections of future water demand are problematic, at b They require speculative assumptions about levels of economic activity and po lation growth, and, just as importantly, quantity and price conditions in water s ply. Water has traditionally been priced below its marginal cost and delive cheaply. Since new supplies will be much more costly than in the past, projecti of demand should not simply reflect past behavior based on low prices. In asse ing future industrial water demand, therefore, we will focus on alternat scenarios of supply conditions.

Assumptions on Population Increase

Growth in population is the conventional starting point for water dem projections. Over the 40 year period from 1980 to 2020 many futures are possil In the absence of catastrophe, the demographic structure of the state's populat and its attraction for domestic and international migrants indicate that substan growth is probably inevitable. How much depends upon the assumptions select Estimates by the California State Department of Finance suggest the follow range:

1980	2000	2020
23.5 *million*	29.3 *million*	34.9 *million*

These figures are primarily based on extrapolations of present demographic trends. They assume no major obstacles to growth, although both water and housing supply have been suggested as potential constraints that could significantly lower the final total.[11]

Over 40 years the probable error in these estimates is quite large. If we accept a 49 percent increase by 2020 as a reasonable guess, what does such population growth mean for industry? It is reasonable to expect production and income to grow somewhat faster than population. A modest 2 percent per year growth rate in income per capita would imply growth in gross income over the period by 221 percent. In round terms suitable to the reality of error in a 40 year projection, this amounts to roughly a doubling of output. What does this, in turn, imply for industrial water demand? The answer depends upon our assumptions about the composition of production, water supply, and price.

We will consider supply variables by means of three broad scenarios:

(1) *No Project Scenario:* No major institutional or legal changes occur; supply changes only marginally.

(2) *Development Scenario:* Development of further water supplies occurs through a series of projects without major institutional shifts. Projects may include the Peripheral Canal, the filling of New Melones, Glenn Reservoir, Cottonwood Reservoir, Auburn Dam, and Los Vaqueros Reservoir.

(3) *Reallocation Scenario:* Reallocation of water is pursued as an active policy with major changes in law and institutions providing defined and separable property rights in water; no major increase occurs in supply; and development of a marketlike system for sale and exchange of water among willing parties takes place under state sponsorship and regulation.

No New Project Scenario

Without any new surface water storage projects by the state or the federal government, aggregate water supplies will not expand markedly from the approximately 40 million acre-feet now withdrawn annually in California. Indeed, they may decline due to groundwater overdraft and loss of Colorado River water to other states. If we assume that industrial water demand grows proportionately to growth in output, it will about double by the year 2020, to approximately 3.2 million acre-feet. If accompanying residential and public use increases by just 50 percent (the predicted rate of population growth), nonindustrial demand will rise from about 3.6 to 5.4 million. All together, the urban sector will require an additional 3.4 million acre-feet. Given this prospect, four alternatives (or combinations thereof) present themselves for industry:

(1) Industry develops more supply on its own. Since industry already secures a large percentage of its water on its own initiative, blockage of public water supply expansion would undoubtedly spur firms to develop further means of self-supply. Except in coastal areas, it will be quite difficult to secure surface water rights. Therefore, the likely course will be for industry to pump groundwater. Because of its greater capital resources, industry can almost always outcompete other groundwater users by driving its wells deeper. Conflicts between industry and farmers over such competition is common. The difficulty with this solution is that groundwater overdraft will be worsened in many parts of the state.

(2) Industry reduces the intensity of water use. We can be reasonably sure tl the conditions of industrial demand will not remain constant under any c cumstances. Changes in industrial water use may come about for any of the f lowing reasons:

First, intersectoral shifts in economic activity will take place. The trend the past 20 years towards a higher proportion of output in services and higl technical manufacturing will probably continue, with some slowing in rate. Tl will reduce industrial water demand per dollar of GNP because these sectors u less than traditional heavy industry. Evidence of the shift will be quite varial from place to place, however.

Industries will manifest a wide range of patterns in output growth and wa use. For example, decline in the resource base of California's timber indus suggests a reduction in water demand as production shifts out of state. Similar the demand for canned fruits and vegetables has not been strong recently and t industry may continue to show poor growth. On the other hand, as oil fie become less productive and flow enhancement processes are increasingly nec sary, water use will probably rise, as such fields are unlikely to be abandoned the present climate of oil demand.

Second, technical change within industrial sectors may reduce water u even as sectors grow. Because demand is concentrated, improvements in wa use efficiency in a few high-use sectors can offset overall demand expansion d to rising outputs. For example, the aggregate stability in manufacturing dema for water between 1960 and 1970 was due almost entirely to a 68 percent decre in water intake in the wood products industry.[12] This decrease is largely attrib able to technological change in the use of water in storage and preservation logs. One cannot be sanguine about the course of technical change, of cour For instance, the petroleum industry has been quite resistant to change in its recovery practices despite attempts at regulation stemming from concerns o contamination of groundwater by injected brines.

Third, locational shifts may increase water use, if, as seems likely, the sou ern part of the state continues to grow more rapidly than the north, and indus continues to decentralize from the coastal cities into the interior. Higher demar for landscaping and air conditioning can be anticipated, compounded by fashic in industrial and office parks and enclosed shopping centers. This might be off by greater access to self-supply in the Central Valley or by non-process-relat practices such as shifting to electric air-conditioning (which has other proble from the standpoint of energy demand) and toward landscaping with more xe phytic plants.

Fourth, industry will have to respond directly to price and quantity signals water supply. The inevitable price increases and periodic supply shortages whicl No Projects Scenario holds in store will put pressure on industry to adopt inno tions in water using practices. That industry has the capability of responding such constraints is certain. For example, as a consequence of the severe drou of 1976-1977, East Bay Municipal Utility District reported a *permanent* cutback industrial demand between 1975 and 1980 of 17 percent.[13] In another ca significant demand reductions were achieved when the City of Santa Mon recently switched from a declining block to flat rate structure; one fact achieved 60 percent savings.[14]

In sum, the prospects for marginally reduced water intensity in industry and allied urban sectors are probably good, especially as economic signals begin to be felt. But significant reductions will require more dramatic crisis conditions and coordination by government bodies, if the experience of the recent drought is any indication.[15]

(3) Industry suffers restrictions on its growth due to water supply shortages. We find this to be a rather unlikely outcome, for several reasons previously mentioned: the minor role water plays in most industrial processes, the relative capability of industry to respond to supply signals, and the proven cutbacks by industry in selected circumstances. The biggest obstacle to industrial growth from water shortages would likely be constraints on water hookups for new housing development, which could affect labor markets via rising housing costs. It is unlikely, however, that water supply would be allowed to act as a serious growth inhibitor for long.[16] The balance of economic and political power in the state undoubtedly rests with industry and the cities. Although this power is rarely mobilized against agriculture, for a variety of reasons, in a crisis situation it is virtually certain that *ad hoc* measures to shift supply from agriculture to urban water users could be instituted.

Nonetheless, it is by no means clear that perceptions match realities among urban constituencies, who generally do not understand the patterns of water utilization and political power in the state. Economic crisis or even fear of growth slowdowns might well precipitate sharp reactions favoring renewed water project development on a crash basis. Business leaders will probably support such action, as they have in the past. Business typically dislikes uncertainty, as would be likely owing to water supply shortages, and the threat of government regulation, as would be necessary in a supply pinch. The construction and real estate sectors would almost certainly find any supply limitations or forced changes in housing practices distasteful. Some sectors of business closely linked to agriculture will oppose any policy that works to the disadvantage of the latter. Finally, new water projects will be favored by many because of the hydroelectric power and construction jobs they promise.

(4) Industry and urban users receive water from agriculture. If a full 3.4 million acre-feet of water were diverted from agriculture to supply urban-industrial users, the latter's share of the state total would increase from 13 to 22.5 percent and agriculture's share would fall from 86 to 76 percent.[17] Such a major transfer out of agriculture would probably not be legally or institutionally possible under existing arrangements. In some cases, such as the State Water Project, urban contractors have priority over agricultural contractors for firm water supplies, although this priority has never been asserted. Indeed, large amounts of unused water have been transferred to San Joaquin Valley growers each year. In the case of the Lower Colorado River Storage Project, on the other hand, priority goes the other way under an agreement signed fifty years ago. (This would be politically difficult, but not impossible, to change.) In still other circumstances growers and rural irrigation districts have secure water rights that could not be taken away without a major legal upheaval.

It may happen, however, that some agriculturalists will have a surplus which they would willingly part with in the not distant future. This may come about as energy prices force up the cost of pumping for both groundwater and surface water systems (see Chapter V). As water prices go beyond $50 or even $100 per

acre-foot in some farm areas, it will not be profitable to grow many curren profitable crops (see Table 3). Even so, the institutional barriers to transferr this water from agriculture to urban users will remain.

These considerations concerning the No Project Scenario strongly indic that a do-nothing policy in water resources is not in fact possible. It will inevita create conditions of shortage that require a response. In part that response consist of private decisions to conserve. Although the No Project Scenario unlikely to restrict urban-industrial growth significantly, it will be attacked on ground that it will have such an effect. The state will then surely be forced respond, due to the need for coordinated action.

Ultimately, the No Project strategy would do no more than defer hard choi about allocation of water sources that must be made as growth takes place. Under pressure of crisis conditions, moreover, rational policy choices will be difficult make. The No Project policy is not therefore an appealing one for Califorr That leaves two positive policies to be considered.

Development Scenario

Supply expansion is a policy with several cost dimensions, including dir construction costs and environmental costs, which cannot be addressed here. I often assumed, however, that whatever its other shortcomings, full developm will at least solve the water shortage problem; that is, it will bring supply a demand into equilibrium at prevailing prices. Acting on such an assumpti industrialists may, in light of the political implications of the No Project Scenar support development of more storage facilities in the hope that conflict, restrai on growth, and/or forced innovation can be avoided. They are likely to be dis pointed, however.

As noted previously, the industrial sector will require an additional 3.4 n lion acre-feet by the year 2020, ceteris paribus. If all new water projects curren envisioned are constructed in this time, they will generate no more than 3 milli acre-feet of new yield. In other words, even under the full development scenar *projected supply increases will not be sufficient to cover industrial-urban growth, alone allow for expansion of agricultural water use.*

Of course, industrial water demand may not grow at the same rate as outp as indicated previously. If that is the case, then conflicts will be reduced. Bu agriculture absorbs another 2 to 3 million acre-feet of water per year by 20 conflict cannot be eliminated. Even under the most optimistic conditions, ind trial and urban water saving is unlikely to make up the difference, as it wo require cutbacks in use in the range of 40 to 60 percent.

Again we are faced with the hard question of how water should be allocat between, as well as within, the urban and agricultural sectors. Building new p jects does not relieve the citizens of California from the need to have a positi policy concerning the end-uses of water. Some form of efficient and fair syst of water distribution is still required.

Before proceeding to a consideration of the Reallocation Scenario, howev the issue of the costs and benefits of new projects must be addressed, since so new development may be considered under either scenario. From industry's po of view, there are several reasons why new supply projects are a financially un tractive means of securing greater supplies for the industrial-urban sector.

First, such projects have become extremely costly because the best dam sites in terms of proximity, storage capacity, and hydroelectric generating capacity have already been developed. For example, the State Water Project has capital costs of about $45 per acre-foot north of the Tehachapi Mountains.[18] Estimates of the capital cost of additional water run as high as $350 per acre-foot.[19] Add to this, pumping costs will soon rise to $25 to $35 per acre-foot north of the Tehachapis and more than twice that south of the mountains, in metropolitan Southern California (see Chapter I). Supply development does not mean cheap water.

Second, industry, and urban consumers in general, are apportioned a small share of total project yield, compared to agriculture. Most water projects are overkill as far as industry is concerned. For example, the Metropolitan Water District of Southern California has firm water entitlements to only about one-half million out of 4.5 million acre-feet supplied to California from the Lower Colorado River Storage Project, and one million of the 2.3 million acre-feet supplied by the State Water Project—it currently takes only about two-thirds of this share, yielding the rest to Kern County. It would get half of the water from new additions to the State Water Project, as well.

Third, urban-industrial users currently underwrite low cost agricultural water. For example, the Central Valley Project, which delivers 5 to 6 million acre-feet per year to agriculture, has had difficulty paying even its operation and maintenance costs, so low is its cost recovery from user charges. Repayment of capital costs is by hydroelectric revenues and transfers from the federal treasury—costs which urban dwellers pay via higher electricity rates and income taxes. The State Water Project currently involves substantial financial transfers from the rate and taxpayers of the Metropolitan Water District of Southern California to San Joaquin Valley irrigators, because the MWD turns over several hundred thousand acre-feet of "surplus" water a year to agriculture on which it still pays the fixed costs.

Fourth, the proposed expansion of the State Water Project will be financed by means of revenue bonds, which will form a large part of the new bonded debt of the state. California can take on only a limited burden of debt, so these bonds compete for available capital with other kinds of bonds that benefit industry and urban development, such as industrial parks, pollution control investments, and municipal water and sewer systems. Moreover, if the State Water Project experiences any difficulties in repayment by contractors—owing perhaps to demand cutbacks in the face of rising water prices—its revenue bonds will be difficult to sell and California's bond rating, which determines the cost and ease of borrowing, could be jeopardized.

Reallocation Scenario

The most rational policy from industry's perspective would be to reallocate presently developed water supplies. A transfer of roughly 5 percent of agricultural water used in California would amount to a doubling of water available for industrial customers; a transfer of 11 percent would mean a doubling of water available for *all* urban uses. Under the Reallocation Scenario, the water demands of industry and attendant urbanization would be met principally by transfer of 3.4 million acre-feet of presently-developed water supplies from agriculture to urban users. This amounts to approximately a 12 percent decrease in agricultural water use intensity, correspondingly more if irrigated farm output were to expand. This does not appear to be an unachievable figure, compared to the 17 percent permanent reduction of industrial water use in the East Bay service area in only five years.

In fact, the degree of water transfer is likely to be much lower than above figure of 10 percent of all developed supplies. That figure, arrived at by simplest arithmetic, represents an upper bound. More sophisticated calculati of marginal transfers from the lowest to highest efficiency uses arrive at a total less than 3 percent shift in total water use (see Chapter VIII).

A Reallocation Scenario is preferable to the No Project Scenario becaus reduces business uncertainty and eliminates a possible growth crisis due to sup shortages. Reallocation is preferable to Full Development for reasons of c effectiveness. Furthermore, *reallocation is unavoidable in either case, so it is be to consider a positive and creative policy now rather than later when a crisis hits.* Th further arguments can be made in its favor.

First, transfer of water between economic sectors can serve the gene social good. That is, where a presumption can be made that market valuations a good measure of social worth, social welfare is served by the efficient allocat of resources to economic uses where their contribution to production (margi product) has the highest value. One need not accept a full-blown version of w fare economics in order to apply this principle. *At the margin* water is being appl to uses with a lower value-added per acre-foot in agriculture than in indus principally due to lower returns on agricultural than industrial products (see Ta 3). Other sources of inefficiency are losses in transit, low efficiency in applicati a high rate of water use by crops, or low returns on certain products. Thus *b* physical and economic efficiency are involved. And this applies chiefly to the m ginal percent of uses, not the bulk of perfectly reasonable and beneficial appli tions of irrigation water. If only a 20 percent cutback in the lowest valued cr (per acre-foot of water applied)—hay and pasture—were achieved, the amount water would nearly equal the yield of Phase II of the State Water Project. A percent cutback would exceed the yield of the Peripheral Canal alone.

The second argument for transferability is that it is cheaper for industry (a other urban uses) than other possible sources of water. For example, Color River water now being sold for under $5 per acre-foot to the Imperial Valley co be purchased for from 15 to 70 times its present price and still be competit with water generated by the various new supply augmentation projects on drawing board.

Conversely, a grower who could sell water acquired at low prices would st to make a healthy profit. Saleable water would become available either thro conservation measures (more efficient transfer and application), altered cropp patterns (shift from more to less water intensive crops), or withdrawing land fr production of irrigated crops. Each of these alternatives normally has a cost as ciated with it. But the revenue to be gained from the sale of water will freque exceed the cost of generating a salable surplus through purchase of better irri tion equipment, lining irrigation ditches, or foregoing revenues on idled land.

For example, the average value of output in hay and pasture per acre-foo water applied is only $70 (see Table 3). Urban users could pay more than this acre-foot and still the water would cost less than from all but one of the units the proposed expansion of the State Water Project—and considerably less than average cost of water from the whole of Phase II of the State Water Project, wh has been estimated to be $225 per acre-foot. Meanwhile, farmers will make m by *not* growing alfalfa (which also has other input costs) than by growing it.

The possibility of financial gain to the growers under a reallocation scheme is of crucial importance. Abstract considerations of "social welfare gain" are of little use in generating political support for water transfers. To be politically viable, a reallocation strategy must also be essentially *marginal* involving no more than 20 percent of the farm total over the next 50 years, and occurring through carefully regulated trading, in limited circumstances and for restricted purposes. This would allow smooth growth and change in the state's industrial base without serious disruption to agriculture. If, on the other hand, reallocation were taken to mean a full "market solution" applied to all presently-held water rights and contracts, its impacts would be unpredictable and its political palatability would be nil. The ultimate success of a reallocation policy will depend upon whether it is perceived as a gradual or radical change.

CONCLUSIONS

We support a proposal for limited market transferability of water in the State of California. It is, we believe, the best method of dealing with the problem of supply shortage and conflict between sectors over the distribution of water resources.

Any reallocation of water resources, however, must occur at the margin, beginning from the present base. This requires, first, certainty of tenure, or firm property rights. Second, *there can be no permanent forfeiture of rights through sale of surplus water.* Transfer must be defined as a "reasonable, beneficial use" and take place on a periodic basis. In addition, one must have rights over "salvage water," saved by conservation measures. At the same time, other users must be protected. Normal unrecovered excess water (unconsumed) needed by downstream users for streamflow protection and groundwater recharge must be left in place.

If supply augmentation becomes necessary in the future, the state must still plan the size of new additions and the distribution of new water among competing claimants. This cannot be done simply by the market. First, allocation of new rights would be a highly charged issue. Second, the changing cost curve of supply means that past demands based on past costs are not a good measure of future demands. Third, water supply investments are notoriously "lumpy," so there is no possibility of marginal adjustments in output.

A "true" water market would allow for the possibility of permanent transfer and alienation of rights. This is not our suggestion. Water is too essential in California to go simply to the highest bidder. Indeed, our Reallocation Scenario would not eliminate existing subsidies to certain water users, especially irrigators. It merely tries to improve the efficiency of water use given initial positions and financial discrimination, by enlisting the profit-seeking tendencies of present users. Under a modified water market system, industry would benefit without great injury to agriculture.

REFERENCES AND NOTES

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147-156; John McGregor, "Water as a Factor in the Location of Industry in the Southwe *Southeastern Geographer,* 10(1970):1, 41-54.
2. Electric utilities in particular are excluded because they are treated in Chapter V, and because is unreliable for this sector.
3. Data from the California Department of Water Resources generally refer to water withdrawn not to consumptive use. See Tables 1-3.
4. California Department of Water Resources, *Water Use by Manufacturing Industries in Califo 1970,* Bulletin No. 124-2 (Sacramento: The Resources Agency, 1977).
5. Note that the industrial categories in Table 3 are not identical in definition to those of Tabl Note also that a better measure of water intensity, for which commensurate data were available, would be value added per acre-foot of water.
6. Considerably more information would be needed on cost, structure, input-output relation gro dynamics, and social valuation, before concluding that such transfers are necessarily the policy, however.
7. Industrial firms are usually the largest single consumers from public systems.
8. There are very few private water utilities; San Jose Water Works in Santa Clara County and C fornia Water Service Company, which serves areas scattered around the state, are two not exceptions.
9. *Water Use by Manufacturing Industries,* op. cit.
10. M. Storper and R. Walker, "Urban-Rural Subsidy in Financing the State Water Project," unp lished manuscript.
11. L. Kimball and D. Shulman, "Growth in California: Prospects and Consequences," *Public Af Report,* 21(1980):5.
12. *Water Use by Manufacturing Industries,* op. cit., p. 21.
13. Officials of EBMUD, personal communication, August 15, 1981.
14. Testimony of Chris Reed, member, Santa Monica City Council, before the Assembly Commi on Water, Parks, and Wildlife, Los Angeles, December 2, 1981.
15. William Bruvold, "Residential Water Conservation: Policy Lessons from the California Drougi *Public Affairs Report,* 19(1978):6.
16. See Richard Walker and Matthew Williams, "Water from Power: Water Supply and Regi Growth in the Santa Clara Valley," unpublished manuscript, Department of Geogra University of California, Berkeley, 1981.
17. The difference from 100 percent is made up by government water use.
18. M. Storper and R. Walker, "Urban-Rural Subsidy . . .," op. cit.
19. The urban consumer's water bill will not increase proportionally to the increased cost of new w because of mixing old and new supplies and the large component of fixed capital in the tr ment and distribution system.