An International Comparison of
Trends in Water Resources Management

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As worldwide demand for water steadily grows, it is increasingly important that the legal rules governing the management and utilization of water resources actively promote, rather than impede, efficiency in the use of water.¹ Historically, the development of water law has not always been in accordance with such principles, except where compelled by climate or extreme water scarcity. This Article will present a survey of contemporary problems in water use and trends in the shaping of water law to cope with the rising demand for water, focusing on legal regimes that encourage conservation, recovery, and reuse. The scope will be international, in order to consider the widest range of circumstances and allow comparison of many different attempts to mold water law to fit the contemporary necessities of efficient use.

¹ See generally on the worldwide scale of the problem, United Nations, Department of Economic and Social Affairs, Natural Resources/Water Series No. 3, The Demand for Water: Procedure and Methodologies for Projecting Water Demands in the Context of Regional and National Planning, U.N. Doc. ST/ESA/38 (1976). According to this study, total withdrawals of water per capita in cu.m./year in India in 1968 were 600 and are expected to reach 850 in 2000; in Japan they were 710 in 1965 and are expected to be 970 in 1985, in Mexico they were 920 in 1970, rising to an anticipated 1,100 in the year 2000, and in Tanzania they are expected to rise from 36 in 1970 to 200 in the year 2000. Id. at 6 (table 2). By comparison, total per capita water withdrawal in the United States in 1965 was 2,300 cu.m./year. Id. at 5 (table 1). The U.S. Water Resources Council estimated total withdrawals at 270 billion gallons daily (bgd) in 1965, rising to an anticipated 1,368 bgd in the year 2020. U.S. WATER RESOURCES COUNCIL, THE NATION'S WATER RESOURCES 1.23 (1968).
To appreciate the problem areas to be discussed in this paper, it is necessary to trace some aspects of formulation of the basic rules of law that govern the use of water.

Through immemorial practice, slowly developing customary rules attempted to implement the best available methods under the circumstances in which they arose. In order to minimize losses by evaporation and seepage in hot, arid lands, Moslem law prescribed that upper riparians be served first with water and that the quantity should not reach over the ankle. Centuries later the early prior appropriation system in the United States provided that the amount of water that could be used for beneficial purposes, in itself a very imprecise concept, should be measured merely by the capacity of the ditch.

Once such traditional methods become law, they are difficult to change by customary processes even when improved technologies and more precise measurements exist. Written law is an advance on customary law in fostering efficiency. Nevertheless, customary law prevails even today in the form of the riparian rights doctrine in areas where there is still a comparative abundance of water, such as the Eastern United States and England. Its slow and sporadic evolution from the natural flow version to the reasonable use doctrine illustrates the difficulties inherent in modernizing customary water law.

In England and the United States it was recognized long ago that riparian landowners were entitled to a reasonable use of the water flowing past their lands. The courts developed a body of criteria to test a priori the reasonableness of use, which came to be called the natural flow version of the riparian doctrine. According to this version of the doctrine, water can be used only on riparian land, which is generally defined as land abutting a stream and has been held by the courts to include an area of manageable proportions. The water can be used for domestic purposes to whatever extent is necessary, but other uses on

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4. The discussion below of the riparian doctrine is based on Teclaff, What You Always Wanted to Know About Riparian Rights, But Were Afraid to Ask, 12 Nat. Resources J. 30 (1972) [hereinafter cited as Teclaff, Riparian Rights].
6. These uses include drinking, washing, cleaning, and watering livestock. Evans v. Merriweather, 4 Ill. (3 Scam.) 492 (1842).
7. The bounds of necessary use are explored in 7 R. Clark, Waters and Water Rights § 614.2 (1976) and cases cited therein.
riparian land are reasonable only if they do not interfere with the existing uses or, in some jurisdictions, even with the future uses of other riparian landowners. Thus, if a use reasonably depletes water that flows through or by the land of a downstream riparian landowner, it can be prohibited even if it does not cause any actual injury.

This version of the riparian doctrine is an extreme example of appurtenance of water right to land and has all the characteristics of wastefulness that are attributed to appurtenance in general. However, through its prohibition of interference with existing and future uses, this rule does help to protect waters from pollution and permits the accommodation of new uses. But these great assets are offset by lack of certainty of the right. No riparian landowner can be sure of how much water he is entitled to before adjudication by the courts, and adjudication itself is never final because it must be repeated whenever new uses are initiated. New uses can be initiated at any time, the only requirements being confinement to riparian land and exercise of the use by the riparian landowners.

Domestic purposes apart, the riparian rights doctrine gives first preference to nonconsumptive uses, and consumptive uses are permitted only to the extent that they do not sensibly deplete the resource. Theoretically, it is possible to switch uses, since riparian rights are a kind of property right and can be detached from the land and conveyed separately. But such separated rights must be exercised on riparian land and may not change the existing pattern of use without running the risk of being enjoined.

It is small wonder that this doctrine developed in areas rich in water, where irrigation was not a vital necessity. Some of its deficiencies were recognized quite early, and an attempt was made to correct them by abandoning the a priori criteria of reasonableness for a version of the riparian doctrine under which reasonableness was to be tested in each instance in the light of all applicable circumstances. Under this version, consumptive uses are permitted, but the requirement of appurtenance of use to riparian land, which has been retained in most jurisdictions in the United States, makes transfer of rights to other perhaps

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9. Gehlen v. Knorr, 101 Iowa 700, 70 N.W. 757 (1897) (mill owner had to tolerate reduced stream flow so that an upstream user could fill a pond to make ice blocks).

10. Strictly speaking, all uses of water are consumptive. Consumptive uses here means those uses that contemplate a substantial reduction of supply, such as irrigation. Nonconsumptive uses are beneficial but do not result in planned supply diminution, such as generation of hydroelectric power. 1 R. CLARK, supra note 7, § 55.2 (1967).

more productive purposes, or to other land, almost as difficult as under the natural flow version.  

A modified and limited form of the riparian rights doctrine developed under French influence in civil law countries. It restricts the doctrine to unnavigable streams and permits the use of water for irrigation of a riparian owner's land. However, all the land irrigated must be within the same drainage basin, because the water must be returned to the stream after use. In England and Wales the riparian rights doctrine has been modified even more extensively in order to adapt it to modern requirements. The 1963 Water Resources Act introduced a permit system for sprinkler irrigation, industrial use, and use on nonriparian land, but allowed riparian landowners to retain their former water use rights on riparian land for household use and irrigation other than spraying. By increasing administrative control and by permitting use on nonriparian land, such modifications are designed to promote greater efficiency than was possible under earlier systems.

The prior appropriation doctrine, which evolved in the semi-arid Western United States where the common law riparian doctrine was found unsuitable, became quickly embodied in the written law. Although originally it was sufficient merely to divert water and put it to use in order to acquire a water right, in most Western States it became necessary to acquire a permit. Although prior appropriation by no means eliminates waste, it does allow a more precise determination of water rights than the riparian rights doctrine. Both doctrines create a possessory right, but unlike riparianism, prior appropriation allocates a definite amount of water for a definite purpose. Another important advantage of prior appropriation is that water rights are separate from ownership of land.

Modern water codes as a rule embody an administrative system of water disposition, which not only establishes more precise rules than customary systems, but also provides, through administrative permits, for a swifter and smoother adaptation to changing needs.

12. But the protesting downstream owner often had to show injury before a cause of action arose to stop the nonriparian use. Stratton v. Mt. Hermon Boys' School, 216 Mass. 83, 103 N.E. 87 (1913).
15. For a short history of the development of the prior appropriation system, see 1 R. Clark, supra note 7, at 74-143 (1967). The unsuitability of the riparian rights doctrine to conditions in the arid and semi-arid West was succinctly stated by the Colorado Supreme Court in Coffin v. Left Hand Ditch Co., 6 Colo. 443 (1882). The court said: "We conclude, then, that the common law doctrine . . . is inapplicable to Colorado. Imperative necessity, unknown to the countries who gave it birth, compels the recognition of another doctrine in conflict therewith." Id. at 447.
codes require an authorization for some or all water uses, but regulation differs from region to region and country to country, and hence is difficult to define in a brief compass.\textsuperscript{17} The advantages and disadvantages of administrative systems will come more clearly into focus in the following discussion of particular aspects of water law.

The spread of written water law has caused a shift from the traditional choice between customary and enacted laws toward a choice between specialized and comprehensive water laws in deciding how to promote or safeguard efficiency of use. Historically, water laws were scattered in numerous separate enactments and were use-oriented; each type of use was governed by its own individual laws.\textsuperscript{18} The modern trend is toward consolidation of water law, paralleling the contemporary trend toward consolidation of water administration. Together they enhance efficiency, since it is more effective to have one administrative entity administer a single body of laws. Not only does this help to eliminate contradictions and conflicts in interpretations, but planning, an essential element of efficient water utilization, is made easier. Hence, comprehensive codes appear even in the Eastern United States, a region which is water-rich and is the principal remaining stronghold of the riparian rights system.\textsuperscript{19}

II

CONTEMPORARY PROBLEMS IN WATER USE AND THE IMPACT OF REGULATION

The complex problem of control of water resources for efficient

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  \item New Zealand, for example, had more than 100 separate enactments concurrently in force containing provisions on water or water management. \emph{See} I Water in Asia, \textsuperscript{17} supra note 17, at 104-06.
\end{itemize}
use is intimately connected with the nature of private rights in such resources. Legal systems in which ownership is left undefined, e.g., a riparian rights system, give the governing authority relatively little control over an individual’s use of water. In many such situations, the role of the government is limited to the resolution of disputes between private parties, with no capacity for effective planning or direction of resources. 20

In many jurisdictions, administrative authority over water is founded upon state or public ownership. The Peruvian General Water Act of 1969, for example, purports to abolish all private rights in water. 21 Similarly, Israeli and Iranian statutes provide that water is a public resource subject to the complete control of the state for the purpose of serving the needs of the inhabitants and the national interest. 22

The degree of public ownership of water varies between jurisdictions. Generally, it can be said for systems in which both public and private rights exist that private waters have less economic significance. The Spanish Law of Waters of 1879, for example, allows private ownership of water that begins on private land so long as the water remains on private land. 23 Italian law makes public interest the principal test for ownership. 24 Under Argentine law, any private water rights enumerated in the Civil Code cease to be such when the water is needed to satisfy public requirements. 25

The outstanding exception to the statement that only waters of lesser economic significance are private is ground water. Until quite

20. On the different development of riparianism in civil law and common law countries, see generally Teclaff, Riparian Rights, supra note 4.

21. General Water Act, Decree Law No. 17,752 of July 24, 1969 (Peru), trans. in 19 Food & Agric. Legis., Sept. 1971, at V/4a. The Peruvian statute declares in Article I: “All waters, without exception, shall be the property of the State, and ownership thereof shall be inalienable and immune from prescription. No private ownership shall subsist in respect of water or of any acquired rights thereto. . . .” Id. art. 1.

22. The Israeli Water Law of 1959 states that: “The water resources in the State are public property; they are subject to the control of the State and are destined for the requirements of its inhabitants and for the development of the country.” Water Law, Law No. 5719 of 1959, ¶ 1, 288 Sefer Ha-Chukkim 169, 13 Laws of the State of Israel 173 (1958-59). The Iranian Water Law of 1968 provides: “All waters . . . are considered as the national wealth and belong to the public. . . .” Water Law of July 18, 1968, and the Manner of Water Nationalization (Iran), trans. in 11 Water in Asia, supra note 16, at 217. Similar language is found in several state water codes of the United States. See 1 R. Clark, supra note 7, at 242 (1967).


recently, percolating ground waters formed the most important category of private waters. In common law countries, such as England, they have been at the almost unrestricted disposal of the holder of the overlying land and, according to an extreme version of the doctrine, even malicious use of water was permissible.26 The French Civil Code permitted a landowner to sink wells on his property even if, by so doing, he drew on the water supplies of neighboring lands.27 Spain still maintains a long tradition, enshrined in the laws of 1866 and 1879 and in the Civil Code of 1889, that private ownership of land entails private ownership of percolating ground water.28

In these and other jurisdictions, however, the private character of ground water has been modified considerably within the past few decades. A process of curtailment of common law rights began in England in 1945 and in Victoria, Australia, in 1969, though it was accomplished without actually placing the resource in state or public ownership.29 The landowner's rights in France were diminished by a 1964 law which requires that ground water extraction for other than domestic purposes be supervised by the administration.30 Certain ground water areas in Spain have been subjected to governmental control31 and Argentina, a country influenced by Spanish water law, has placed ground water among public waters, although the landowner still retains preferential use of it.32 It is only when all waters are within the legal control of the administration that the efficient use of water, in so far as the general economic and social conditions of a country permit, is most likely to be achieved.

A. Constraints Imposed by Preexisting Uses

One of the gravest obstacles to efficiency and economy in water

use, and especially to the introduction of a more appropriate system of water law to achieve that objective, is the existence of prior rights which cannot be abrogated without severe technological difficulties and considerable social and economic upheaval. The quest for efficiency in utilization of scarce water resources may require the cancellation of many existing uses in order, so far as is practicable, to begin anew with a system that more adequately protects the public interest. However, in most legal systems water uses are considered either property rights or administrative rights entitled to protection. In any case, the development and use of water resources very often involve a heavy investment in money, time, and labor; the sudden abolition of existing uses would cause economic hardship and uncertainty. The question then becomes: what new elements should be introduced and which old elements should be retained? Solutions range from leaving the old rights unaffected side by side with the new regime, through assimilation into new regimes after a grace period, to virtual abolition of preexisting rights.

Laws that leave preexisting uses unaffected by a new regime may bring about a complicated and inefficient situation in which different regimes apply to the same source of water. Statutes that contain such provisions include the Spanish Law of Waters of 187933 and the Philippine Irrigation Law of 1912.34 Similarly, in some states of the Western United States prior appropriation coexists with riparianism.35 Bolivian law continues to recognize water rights in existence before the Agrarian Reform Law of 1953.36 In Chile, water rights were expropriated, but prior users were given the right to continue their uses without complying with the administrative procedure for obtaining a concession.37

Laws that assimilate preexisting uses into the new system after a grace period represent the modern trend in water law. They eventually give the administration full control, while making the transition less painful for users who, for reasons of economy and efficiency, may re-

35. See, e.g., Wasserburger v. Coffee, 180 Neb. 149, 141 N.W.2d 738 (1966). This case illustrates the complexities that can arise from the perpetuation of both systems in one state. Riparian rights in Nebraska are limited to lands privately owned before 1895 that meet certain conditions. Id. at 155, 141 N.W.2d at 743-44.
36. D. DAINES & G. FALCONI H, supra note 17, at 97. The Peruvian Land Reform Act of 1964 introduced a significant new condition—that preexisting rights be in harmony with “social interest.” Land Reform Act, Act No. 15,037 of May 21, 1964, art. 110 (Peru), trans. in 13 FOOD & AGRIC. LEGIS., June 1965, V/1b, at 29. This requirement marked the end of automatic recognition of preexisting rights and gave a flexible yardstick by which to measure their usefulness.
37. D. DAINES & G. FALCONI H, supra note 17, at 56. Prior water rights were abolished in Peru in 1969, and in Ecuador in 1973, but prior users could convert their previous rights into new rights by complying with provisions of the new law. Id. at 137, 169.
receive less water or be forced to alter their pattern of use. The State of Mississippi adopted this “conversion method,” as it is known, when it replaced its riparian rights system in 1956 by a prior appropriation system. It did not exempt existing riparian rights from the new procedure, but gave the riparians priority and first opportunity to perfect their rights. The United Kingdom also adopted the conversion method when it introduced the Water Resources Act of 1963. Users under earlier laws were entitled as of right to a license required under the new law, on condition that they made application in the prescribed form and within the prescribed period of time, five years. The grace period was much shorter under the 1963 Water Code of La Rioja Province, Argentina, which gave previous users the right to a new concession only if they applied within one year, and shorter still under Israel’s Law No. 5719 of 1959, which required previous users to apply within ninety days. Generally, upon conversion of old rights into new, the user is entitled to the same quantity of water as before.

The most radical approach is found in some recent codes that virtually abolish preexisting uses by making their assimilation into a new permit system mandatory, immediate, and subject to their conformity with national or regional plans. This gives the administration much more control over water allocation, so as to further the particular interest to be promoted, whether land reform or efficiency in water use, but also creates the potential for great harm to existing users if exercised arbitrarily. In Poland, the Water Law of May 30, 1962, provided that rights previously acquired retained their validity only if they were not at variance with general water plans to be determined by the administration granting the permit. Thus there was not a straight conversion of old rights into new ones; the old rights could be approved in each instance, but the effect was almost complete abrogation of preexisting rights. Iran’s Water Nationalization Law of July 18, 1968, gave holders of preexisting rights a claim to have them converted into permits, but left the extent of their use under the permit to be determined by special committees appointed for that purpose. The committees were empowered under the act to consider the quantity of water, amount of

42. The Water Resources Act, 1963, c.38, § 34 (Eng. & Wales), guaranteed existing uses the same quantities of water as before, provided that the use complied with certain statutory provisions.
land, place of use, efficiency of use, and local customs. The converted use could thus be very different from the previous right.

B. Preference of Use

Almost all water laws rank uses, and in some cases users, in a certain order of preference. This ranking represents the community’s appraisal of the social and economic value of particular uses at a given time and serves as a guide for the apportionment of water between new applicants. Where more efficient water use and reuse are desired, therefore, the ranking of uses can be either a help or a hindrance, depending on how the preference is expressed. Lists of uses in order of preference are spelled out in many water codes, but unless they are of very recent date, such lists tend to embody social and economic criteria that are no longer pertinent to the present circumstances and may hamper the water administration in promoting economical and efficient exploitation of the resource.

Domestic uses almost invariably command the highest priority. When this class is confined to individual or household needs, relatively small amounts of water are consumed and no significant diversion of the water supply results. Ground water is the exception to this generality. For instance, in the Black Hills region of the Dakotas, ground water has been depleted by uncontrolled extraction for domestic purposes to such an extent that South Dakota law now makes the priority contingent upon the exercise of domestic use in “a manner consistent with the public interest.” Certain codes absolutely limit domestic uses of ground water reserves to ensure that these reserves are not dangerously depleted. The limitation is established in various ways, for example, by the quantity that may be extracted or, if the irrigation of lawns or gardens is included, by the maximum amount of land that may be so watered.

45. See, e.g., Water Law of 1906, § 204, [1906] Anuario de Leyes 414 & App. (Bolivia); Water Law, Law No. 5,719 of 1959, ¶ 6, 288 Sefer Ha-Chukkim 170, 13 Laws of the State of Israel 174 (1958-59); COLO. CONST. of 1876, art. XVI, § 6 (in time of shortage); IDAHO CONST. of 1890, art. XV, § 3. See also 5 R. CLARK, supra note 7, § 408.1 (1972) and sources cited therein. For a description of the de facto priority scheme in Wisconsin, see Lowe, Ruedisili & Graham, Beyond Section 858A: A Proposed Ground Water Liability and Management System for the Eastern United States, 8 ECOLOGY L.Q. —, — (1979).


48. E.g., Water Law of July 18, 1968, and the Manner of Water Nationalization, art. 25 (Iran), trans. in II Water in Asia, supra note 16, at 220, which imposes a limit of 25 cubic meters in 24 hours on domestic, drinking, sanitary, and gardening use from ground water.

49. In Oregon and South Dakota the amount of land included in the definition of domestic use or exempted from permit requirements is one-half acre. OR. REV. STAT. § 537.545 (Supp. 1973); S.D. COMPILED LAWS ANN. § 46-1-6(4) (Supp. 1974). In New Mexico’s designated ground water basins it is one acre. N.M. STAT. ANN. § 75-11-1 (1968).
When the preference accorded domestic use extends to municipal and community water supplies, it can involve huge amounts of water and considerable waste. Large institutions, hotels, commercial establishments, factories, harbor facilities, airports, parks, and ornamental plantings all benefit from the domestic use priority if they take their water from municipal mains. Many water codes explicitly create such a priority. For instance, the Venezuelan law of December 30, 1965, states that concessions for public waters may never be given if they are prejudicial to water supply to inhabited areas, and the California Water Code provides that a permit application by a municipality "shall be considered first in right, irrespective of whether it is first in time." The preference is also explicit when municipalities are accorded the right of eminent domain. Under authority contained in its Administrative Code, for example, New York City was able to condemn riparian rights and acquire waters in the Upper Delaware Basin. Texas law subordinates appropriations for other than domestic or municipal purposes to the right of any city or town to make further appropriations for domestic and municipal purposes without the necessity of compensating the existing appropriators.

The statutory imposition of a fixed order of preference in uses establishes rigid guidelines which must be followed by the administration, but concepts of public interest and public welfare embodied in some codes provide flexibility. For instance, Utah law contains a list of beneficial uses, but provides also for refusal of a permit if the public welfare would be adversely affected by the proposed use. The 1969 General Water Act of Peru expresses a more elastic method of dealing with the problem, allowing the administration to vary the listed order of preference by considering "the characteristics of watersheds or systems, availability of water, water management policy, land reform plans, uses conceived in the greater social and public interest and uses in the greater economic interest." The Italian law of 1933 goes a step further, making public interest the sole or main criterion in evaluating

53. Tex. Water Code Ann. tit. 2, § 5.028 (Vernon 1972). See also Ariz. Rev. Stat. § 45-143 (1956), which states that applications for municipal uses may be approved to the exclusion of all subsequent appropriations if the estimated needs of the municipality so demand.
uses. In times of shortage the administration in some jurisdictions is given virtual carte blanche to set up a system of priorities for any purposes considered vital. For instance, the Chilean Land Reform Act empowers the president to issue a decree providing for the total or partial extinction of any usage right when water must be supplied for domestic purposes. Authority may be given to establish special protected zones or areas, as in the Israeli law of 1959 which provides that any license in water rationing areas may be cancelled or varied. Special areas have been proclaimed in many parts of the world to protect ground water from depletion, and legislation accords water administrations wide-ranging discretion in the apportionment of supplies among uses and users. A number of the western states of the United States have legislation providing for the establishment of "designated" or "controlled" or "critical" areas of ground water regulation. Among the actions that the water administration may be authorized to take in these states are: closing the areas to new users; apportioning withdrawals among existing users; establishing use preferences without regard to priority; and reducing or prohibiting withdrawals by some users. In a few instances even the drilling of wells for domestic or municipal purposes may be prohibited. Some states, however,

56. Royal Decree No. 1,775 of 1933, art. 9, V Rac. Uff. 30 (Complementare 1933) (Italy), requiring concession applications to be weighed primarily from this point of view.
63. NEV. REV. STAT. § 534.120 (1973); OR. REV. STAT. § 537.735(3)(c) (1977).
65. NEV. REV. STAT. § 534.120(3) (1973) (when the area is served by a water supplier, the State Engineer may limit the depth or prohibit the drilling of domestic wells). In Jarvis
continue to regulate withdrawals within these special areas according to priority of appropriation.\textsuperscript{66} By contrast, Oklahoma has abandoned prior appropriation in ground water use and applied the concept of critical areas to the entire state (just as Israel expanded water rationing areas to cover the whole country).\textsuperscript{67} 1972 Oklahoma legislation requires the water administration to determine each ground water basin's maximum annual yield and allocate it by shares according to the percentage of overlying land held.\textsuperscript{68}

C. Quantification of Water Rights

Quantification of water use rights, that is, limitation on amounts of water that may be used, is a key element in the economical and efficient use of water. The extent to which the water administration quantifies rights depends largely on the total amount of water available, the characteristics of its occurrence, and the nature of the uses to which it is put. In areas with abundant water many uses are not quantified with any precision, whereas in areas with little supply and great demand even minor uses are strictly limited in the amount that may be consumed. The extent of quantification may also be determined by factors that have nothing to do with current availability of water or present demands on the resource, but relate to past uses, outmoded technologies, and rigidities in the legal system.

One element of quantification which enables the water administration to control total withdrawals from a surface stream is the requirement that a certain minimum flow be left. Minimum flow provisions are found in the 1963 Water Resources Act of England and Wales,\textsuperscript{69} in the French Rural Code,\textsuperscript{70} and in the Salta, Argentina, Water Code.\textsuperscript{71} The requirement arises also in the case of water diversion for hydroelectric power development. Hydroelectric power concessionaires in Switzerland, where projects such as the Grande Dixence divert virtually all the waters of several watersheds, have been required to ensure minimum discharges over the whole or part of a year, so as to maintain

\textsuperscript{66} Montana law provides that where the aggregate withdrawal has been ordered decreased, the decrease must conform to priority of rights, except for domestic use. MONT. REV. CODES ANN. § 89-2915 (Supp. 1975.)

\textsuperscript{67} OKLA. STAT. ANN. tit. 82, §§ 1020.1-.22 (West Supp. 1977-78).

\textsuperscript{68} Id. §§ 1020.5-.6 (for nondomestic uses).

\textsuperscript{69} Water Resources Act, 1963, c. 38, § 19 (Eng. & Wales).

\textsuperscript{70} CODE RURAL, art. 97-1, Law No. 64-1245 of 1964, [1964] D.S.L. 11, 47 B.L.D. 674 (1964) (France).

\textsuperscript{71} Water Code of 1946, Law No. 775 of 1946, arts. 44, 184-189, [1951] B Anales 2027, 2036 (Argentina, Salta) (regulation of flow is a basis for calculating the apportionment of water between users).
the safe yield of diverted rivers. Minimum flow provisions to protect fresh water supplies from salt water intrusion are contained in the Federal Water Pollution Control Act Amendments of 1972, which authorize federal agencies involved to determine the need for discharge of stored water in regulating streamflow for that purpose.

Several of the states have their own enabling statutes for setting minimum streamflows and lake levels. It is their general policy to deny authorizations for uses that would encroach upon the minima established. States calculate minimum flows in various ways. Mississippi bases its determination of the minimum on an average of the lowest flows of record over a particular period. Florida defines minimum flow as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area."

Among all the uses of water, irrigation is the one with the longest history of quantification of rights and the greatest potential for economy through efficient practice. The quantity of water that a user may receive for irrigation has been designated in many ways: by share of the supply, in terms of concepts such as "beneficial use" or "duty of water;" by unit of land; or in terms of crops grown. The amount itself may be measured by depth of water, volume of water, rate of flow, or by a time-turn system. Sometimes these details are spelled out in legislation, and sometimes they are left to the discretion of the water administration or the determination of the courts.

The expression of quantity as a share of the total supply of water is especially a feature of a riparian or modified riparian system, where water use rights are virtually confined to lands abutting the stream. In South Africa, the riparian landowner can use the normal flow of a pub-

74. FLA. STAT. ANN. § 373.042(1) (West 1974); IOWA CODE ANN. § 455A.1 (West 1971); MISS. CODE ANN. §§ 51-3-3(i), 51-3-7 (5) (1973); WASH. REV. CODE ANN. § 90.22.010 (Supp. 1977).
75. MISS. CODE ANN. § 51-3-3(i) (1973).
76. FLA. STAT. ANN. § 373.042(1) (West 1974).
78. D. Baker & H. Conkling, Water Supply and Utilization 398 (1930); 1 R. Clark, supra note 7, § 55.3; 5 id. § 408.2 and sources cited therein.
80. 5 R. Clark, supra note 7, § 408.2. See also Arlosoroff, supra note 58, at 12.
82. Id. at 137; D. Baker & H. Conkling, supra note 78, at 398.
83. J. Mills, supra note 79, at 135.
84. F. King, Irrigation and Drainage 242-43 (1907).
85. See, e.g., J. Mills, supra note 79, at 133 (1907) (North Dakota, Idaho). (This explicit detail is especially true of older laws.)
86. 5 R. Clark, supra note 7, § 408.2.
lic stream, after domestic purposes of all other owners have been met, in a fair and reasonable proportion determined by the Water Court and consistent with similar rights of lower riparian owners. In riparian jurisdictions in the United States, the share in the flow of a stream is also determined by the courts in terms of reasonable use. For irrigation purposes it has been held that this means equal distribution of stream waters among riparians. But courts have acknowledged that the actual quantity of water may vary from one growing season to another and may differ for different crops, and that where the riparian proprietors owned equal amounts of land it did not mean each was entitled to the same fraction of the total water supply. These limitations contribute to the uncertainty of the riparian system and constitute a major barrier to efficient use. Since many jurisdictions prohibit the use of riparian water outside of riparian land, users have little incentive to economize.

In the prior appropriation system, as developed in the Western United States, quantity is determined by beneficial use. The term beneficial use is somewhat vague and therefore some states have defined it volumetrically for irrigation purposes, either in cubic feet per second (second-feet) for direct diversion (unstored flow) or in acre-feet for reservoir storage. The limits for direct diversion range from one second-foot for each fifty acres in Idaho to one second-foot per seventy acres in South Dakota and Wyoming. For use from storage, the irrigation limit ranges from two and a half acre-feet per acre per annum in California, to three in South Dakota, and five in Idaho. Nevada, which once prescribed quantitative limitations, now leaves the determination to the State Engineer, laying down only general guidelines for

88. Nesalhous v. Walker, 45 Wash. 621, 88 P. 1032 (1907); Frizzell v. Bindley, 144 Kans. 84, 58 P.2d 95 (1936).
89. Redwater Land & Canal Co. v. Reed, 26 S.D. 466, 128 N.W. 702 (1910).
91. See Holmes v. Nay, 186 Cal. 231, 235, 199 P. 325, 327 (1921), in which the court stated that the riparian right includes "the right to a reasonable use of the water of the stream on any portion of the tract which is riparian to it, but not elsewhere." Id. But the Texas Supreme Court held to the contrary in Texas Co. v. Burkett, 117 Tex. 16, 25, 296 S.W. 273, 276 (1927), declaring that: "It is, however, the rule, which we think applicable in this state, that the riparian owner has the right to divert riparian water to nonriparian lands, where water is abundant and no possible injury could result to lower riparian owners." Id. See generally on this subject, Teclaff, Riparian Rights, supra note 4, at 40-47.
92. On this fundamental principle in the water law of the western states, see, e.g., 1 W. Hutchins, supra note 3, at 9-11.
Calculations of quantity based on a multiplicity of factors, rather than on a simple volumetric figure per hectare or per acre, are a feature of some legislation. For example, the Iranian Water Nationalization Law of 1968 authorizes the water administration to determine the water consumption of each crop on each hectare of land, and on that basis to define the quantity required. Further refinements toward the elimination of waste in irrigation may be achieved by imposing rotations in the supply. Taiwan has introduced a system whereby water is supplied according to the requirements of the crop, in definite amounts at the proper time, and in order of established sequence. Such rotation schedules have been imposed by the courts in parts of the Western United States where significant water savings might result. The concept is by no means a modern one: time-turn systems of water delivery have been regulated for centuries by Moslem customary law.

To the extent that a water law system penalizes water conservation, it will hinder the introduction of less wasteful alternatives to traditional gravity flow irrigation. Many courts, even in the water-short Western United States, have held that customary or traditional irrigation practices are legally acceptable despite ample evidence of the wastefulness of such techniques. In a landmark California case, the state Supreme Court declared that an appropriator was entitled to use water "according to the general custom of the locality," and did not have to construct impervious conduits, despite a showing that conveyance losses of forty to forty-five percent had persisted for more than half a century. Cases holding to the contrary have generally involved situations in which enormous losses of water have been demon-

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95. NEV. REV. STAT. § 533.070 (2) (1973).
97. See 1 Water in Asia, supra note 17, at 43.
99. See MOSLEM COUNTRIES, supra note 2, at 34.
101. Id. This attitude was upheld recently in Erickson v. Queen Valley Ranch Co., 22 Cal. App. 3d 578, 584, 99 Cal. Rptr. 446, 450 (1971). Many state statutes simply make allowance for conveyance losses, seepage, and evaporation, without putting any premium on the elimination of waste by ditch lining and other means, e.g., CAL. ADMIN. CODE § 655 (West 1974); KAN. STAT. ANN. § 47-302 (1973); NEV. REV. STAT. § 533.070 (1973). See text accompanying note 107 infra. Where the federal government builds works and supplies water, however, it can set specific conditions for conveyance. The Colorado Basin Project Act, for instance, requires by the terms of each contract for water supply under the Central Arizona Project, that canals and distribution systems through which the water is conveyed after...
strated. In a Utah case, a ditch company had been obliged to divert through a leaky ditch 323,000 gallons of water per day to supply 20,000 gallons per day for domestic use.102 In an Oregon case, the user had withheld five or six times the quantity of water applied for irrigation purposes in order to activate a water wheel.103

Such a judicial and legal attitude toward waste of resources is particularly deplorable in light of the available means for improving irrigation efficiency. Traditional methods of ditch and flood irrigation are, under ideal conditions, no more than fifty percent efficient, and under normal circumstances may be only ten percent efficient.104 By contrast, drip or trickle irrigation, which supplies water only to the immediate root zone of plants, has achieved a very high degree of efficiency in arid nations such as Israel.105 The World Bank has estimated that the application of drip irrigation in Latin America would enable up to eighty percent of the water used in traditional irrigation methods to be saved.106 Sprinkler irrigation is also far more efficient than gravity flow, although sprinklers allow some losses through wind distortion and infiltration into spaces not occupied by roots. Despite drawbacks to some of these high efficiency systems, there remains a great potential for water savings through their expanded use in this country and elsewhere if the present legal systems sanctioning waste are modified.

Appropriators also tend to claim and use more water than is necessary even by traditional standards, because, according to the concept of actual and beneficial use, they are not entitled to any water that through economy and efficiency, becomes surplus to the amount used in the past. For example, an Arizona court held against a user attempting to salvage water through improvements in transmission, stating that "commendable practices do not in themself [sic] create legal rights."107

its delivery to the contractor be lined to prevent excessive conveyance losses. 43 U.S.C. § 1524(c) (1970).
105. Arlosoroff, supra note 58, at 12-19.
107. Salt River Valley Water Users' Ass'n v. Kovacovich, 3 Ariz. App. 28, 30, 411 P.2d 201, 203 (1966). The Governor's Commission to Review California Water Rights Law advocates abandonment of this notion. The Commission recommends modification of the prior appropriation doctrine to allow appropriators to retain their full rights when they do not use the full amount to which they are entitled because of water conservation efforts. Gover-
The principle has also been applied to ground water interrelated with a surface stream. In 1975 the Colorado Supreme Court held that the removal of phreatophytes that consumed ground water that would otherwise have flowed to join a surface stream did not entitle the user to benefit from the water saved, since it was subject to the priority system applicable to the stream. In contrast, the Chilean Land Reform Act of 1967 provides a clear incentive to the landholder who uses more efficient irrigation techniques by permitting him to irrigate a larger area. The Act establishes a norm of eighty basic hectares of irrigated land, but a landholder already irrigating up to 320 hectares with improved methods and complying with certain other requirements may continue to irrigate that area.

The entire problem of introducing a greater measure of efficiency in water use for agriculture is bound up with the question of return flow and the way in which the law deals with it. In traditional gravity flow irrigation systems, there must be a considerable amount of return flow which rejoins surface streams or infiltrates aquifers and constitutes the whole or a major part of the water rights of subsequent users. It has been held that downstream appropriators cannot force an upper landowner to waste allotted water for the benefit of the lower lands. On the other hand, some statutes actually prohibit any action that might result in a decrease in return flow. Wyoming law, for instance, provides that when there is a change in place and purpose of water use, the quantity of water transferred shall not decrease the historic amount of return flow.

The constraints in the prior appropriation system on the recapture of return flow and on the use of water that has been saved by employing more efficient techniques have been criticized as encouraging waste. The National Water Commission, looking to the future in its 1973 report, urged a change of the law to permit complete recapture of return flow when the right is transferred. The new user should then be enti-
tled to do whatever he sees fit with the water, even to sell it for a different purpose.\textsuperscript{113}

The problem has been dealt with somewhat differently in South American countries, where drainage concessions are given for return flow. These concessions are precarious in that they exist for only so long as water is available, are the first to be curtailed in time of shortage, and, as a rule, are given for a definite term rather than in perpetuity as are original concessions.\textsuperscript{114} Those who hold original concessions for virgin water are neither obliged to waste water for the benefit of subsequent users nor to maintain a permanent return flow.

\textbf{D. Payment for Water and Pricing Systems.}

Pricing can be used as a powerful incentive toward more efficient use of water. Pricing systems under current legislation serve many different purposes, some of which are not related to water use at all, such as contributions to the general fund of local government. It is difficult to single out provisions that encourage economy. Generally, however, any system that charges progressively higher rates as more water is used tends to promote economy, while any system that charges progressively less as more water is used creates an incentive for excessive consumption and wasteful practices. Absent market restrictions, water will tend to shift to the uses that can afford to pay the most, which may not necessarily be the uses that are considered to be of maximum social benefit. This social problem is particularly evident, for example, when irrigation comes into competition with urban and industrial uses. Without government intervention, agricultural uses might not successfully compete for water. Consequently, in many countries these uses are protected by statutes that provide for subsidization in one form or another to maintain low food prices, promote agrarian reform, or encourage settlement.\textsuperscript{115}

In quite a number of jurisdictions, holders of water rights can draw water directly from the source without charge. Riparians in Victoria, Australia, for example, retain the right to free water even when supplied from a government waterworks although most other riparian rights were considerably curtailed in 1958.\textsuperscript{116} The United States National Water Commission, in its 1973 Report, estimated that nearly two-thirds of the irrigated acreage in the United States was self-sup-
plied, and the use of water was without charge.117 No charge is made in Belgium, Canada, Finland, or the Netherlands for water abstracted directly from sources, and this was generally the situation in the socialist countries of Eastern Europe until very recently.118

Even where water is not supplied free for irrigation, charges by government works are minimal in many parts of the world. The so-called occupiers' rate prevalent in some areas of India usually depends upon the kind and extent of crops grown; it does not take into account the cost of supply.119 In fact, some rates have been deliberately fixed below the commercial value of the water.120 In other areas, irrigators are charged lower rates to induce them to enter into long-term leases for water supply.121 Temporary exemptions from water charges and rate reductions are found in the provincial and state legislation of Argentina and Australia.122 In the United States, the Bureau of Reclamation made long-term contracts for water supply with the objective of promoting settlement and irrigation agriculture. Charges were based on an estimate of users' ability to pay.123

Charges based in some way on measurement of consumption offer the only possible basis for reducing or making more efficient use of irrigation water through pricing, but have rarely been employed to that end. The 1963 Water Resources Act of England and Wales imposes one charge based on the quantity authorized to be abstracted and a supplementary charge calculated by reference to the amount actually used.124 As to ground water abstraction, the Orange County Water District in California imposed pump taxes to give users an incentive toward greater efficiency.125 However, there are drawbacks to volumetric pricing. The Indian Irrigation Commission examined volumetric charging in great detail for implementation on major canals. It rejected this method for a number of reasons that are still valid, especially in under-developed areas: the reluctance of cultivators to adopt the system without knowing in advance the charges to be paid; the prohibitive

117. NATIONAL WATER COMMISSION, WATER POLICIES FOR THE FUTURE 256 (1973) [hereinafter cited as NATIONAL WATER COMMISSION REPORT].
119. Teclaff, Abstraction of Water, supra note 17, at 163, and sources cited therein.
120. Id.
121. Id.
122. Water Code of 1946, Law No. 775 of 1946, art. 100, [1951] B Anales 2031 (Argentina, Salta); Water Act, Act No. 6,413 of 1958, § 80(6), 8 VICT. STAT. 749 (1958) (Victoria, Austl.).
cost and difficulty of measuring water on a field-to-field basis for individual irrigators; the variability of irrigation requirements between wet and dry years, the charges being greater when the cultivator is getting a low return from the land; and the difficulty in fixing suitable rates.126

The situation is somewhat different with municipal and industrial uses, though here too, pricing largely ignores the criterion of efficiency and may bring about exactly the opposite result. For example, a study of 220 United States water utilities showed that the rate structures for over half of them encouraged lawn sprinkling and air conditioning and promoted the location of new industry. Moreover, in some instances rates were manipulated to provide contributions to the general fund of local government, to force the annexation of areas outside a municipality, or to give free water to local government or other facilities.127

Many municipalities have no metering policy, and must charge either a uniform rate or one based on the valuation of land or premises. For instance, the New York City Water Supply Rules and Regulations provide for charges to unmetered premises by annual frontage rents, computed from the front width of a one-story building, with extra charges for additional stories and added baths, showers, and other equipment.128 Where metering has been introduced, however, it appears to have been effective in controlling and even reducing water use. A survey of urban residential water use in humid and arid areas of the United States demonstrated that average daily use in metered areas was significantly below, in some cases less than half as much as, that in flat-rate areas.129 Metering is in effect also in Belgium, Finland, West Germany, the Netherlands, Switzerland, Malta, and Cyprus.130 It is mandatory in Israel, where domestic water bills based on a bimonthly meter reading warn the consumer of excessive water use.131 The consumer is charged for the excess at almost double the cost of the basic quantity. As a result of separate apartment metering, water consumption per capita in apartment houses in Israel has fallen by an average of twenty percent.132

An incremental rate system is used by municipal water works in Japan. There is a basic charge up to a certain utilization level (eight to

127. NATIONAL WATER COMMISSION REPORT, supra note 117, at 254 (table 7-14).
129. NATIONAL WATER COMMISSION REPORT, supra note 117, at 252 (table 7-2).
130. ECE Report, supra note 118, at 48.
131. Arlosoroff, supra note 58, at 23.
132. Id. at 23-24.
ten cubic meters per household per month) and a steeply rising rate thereafter. At the top end of the scale, the charge for domestic use in the six largest Japanese cities in 1975 was three to four times the basic rate. Incremental pricing is also used in the U.S.S.R., East Germany, and Hungary, not only for municipalities, but also for industry. Prior to 1970, when the system was introduced in East Germany, abstractions from lakes, watercourses, and aquifers were increasing at a rate of 2 to 2.5% annually; since then there has been an annual decrease in abstractions averaging more than five percent. By contrast, in South Africa and the United Kingdom, where charges have been minimal, there has been little effect on the amount of water consumed. Such comparisons led the Economic Commission for Europe to conclude in a recent study that:

The experience of ECE countries with charges for the abstraction of untreated surface water has shown that their introduction has led to better recording, metering, and abstraction control and in general to a better utilization of water resources and to a diminution of water abstraction, especially by industry.

E. Reclaimed and Recycled Water

Water reuse and reclamation have been minor factors in water law until quite recently, but are now growing in importance. It has been estimated that extensive reuse of water could meet projected increases in water demand in the United States until the end of the century. Indeed, cities such as New Orleans that take their water supply from the major rivers on which they are located, have long been drinking what is virtually the treated wastewater of an entire river basin. Yet, it is still relatively rare for water that has been deliberately reclaimed and purified to be supplied for drinking or bathing. One frequently cited example is the city of Windhoek, capital of Namibia (South-West Africa), which began in 1969 to recycle part of its effluent to supply drinking water. Another is the Dan project in the sand dune area south of Tel

134. ECE Report, supra note 118, at 48.
135. Id. at 46-47.
Aviv, Israel, where wastewater from the city and neighboring communities is given advanced physico-chemical treatment and infiltrated into the underlying aquifer. After long storage, it is pumped out by means of recovery wells. Older than either of these is the mixed reuse with artificial ground water recharge system employed in the Ruhr region of West Germany for well over half a century. Treated wastewater from municipalities and industry is discharged into the Ruhr River and, after ground water recharge, supplied by water works as potable water to more than five million people throughout the region.

Although the process of polishing the water to accepted standards of purity is costly, the unwillingness to supply potable water from reclaimed wastewater stems not so much from technical or economic factors as from psychological and medical elements. The understandable human reluctance to drink or bathe in such water has solid support from environmental health specialists. The U.N. Expert Group Meeting on the Achievement of Efficiency in the Use and Reuse of Water at Herzliyah, Israel, in 1974 concluded that:

The potential health hazards of highly treated waste water re-use for domestic purposes are still to be determined. Therefore, waste water should mainly be re-used for secondary municipal purposes. To minimize health risks, only countries with a high level of technology for the operating and monitoring of advanced techniques of waste water and drinking water treatment systems should consider re-using water for domestic purposes.

Even in nonpotable water health hazards occur. Pathogenic viruses and many toxic substances survive conventional water treatment and may even acquire enhanced virulence or toxicity in combination. There are dangers in the use of treated wastewater for purposes such as aquaculture, the irrigation of pastures grazed by milk cows, and the irrigation of crops to be eaten raw, fruits and vegetables. These dangers pose a dilemma. For efficiency's sake, should the law compel the primary utilization of only so much water as is absolutely necessary? Or should it permit the utilization of larger quantities of wastewater, with a safety margin in dilution, and then mandate adequate purification for subsequent reuse? To what standards of purity should

140. Id. at 17.
141. Id. at 35.
142. For a discussion of methods of reclaiming water without activating pathogens and toxic substances, see Cillié, supra note 136, at 2-4.
143. A cholera epidemic that occurred in Jerusalem was attributed to the use of wastewater to irrigate vegetable crops. Expert Group Report, supra note 104, at 8. For a detailed discussion of the health aspects of wastewater recharge, see California State Water Resources Control Board, California Dep't of Water Resources & California Dep't of Health, Health Aspects of Wastewater Recharge—A State of the Art Review (1978).
wastewater be treated for nonpotable uses and should treatment methods be used that themselves may pose environmental and health risks?

There seem to be no clear-cut answers even in countries such as Israel and South Africa, where shortage of water compels a considerable amount of reuse. Israel's Dan project had to be modified to meet stricter standards for domestic use of the renovated water, yet for agricultural purposes it will produce a lower quality water which may require a separate conveyance network. In South Africa, where about thirty-two percent of treated municipal effluent is reused, wastewater renovation is based on the requirement that industry purify its effluents to the same standard as that of the waters of origin. Some relaxation in standards is made, however, for irrigation. Where this softening may have a bearing on health, consultation is required with the Department of Health before permits are issued. In the late 1960's, the Department of Health did issue guidelines for the reuse of water of lower than potable quality, but as of a decade later they have not been embodied in legislation.

In the United States, the Environmental Protection Agency seems recently to have come to the conclusion that when proper safeguards are observed, land treatment processes and the use of wastewater on the land have a double advantage: (1) providing nutrients for crops; and (2) purifying the water to an acceptable quality. In a policy statement, the EPA announced that in the future it would press vigorously for publicly owned treatment works to utilize land treatment processes to reclaim and recycle municipal sewage effluent, even to the extent of relaxing pretreatment standards.

Land treatment is capable of achieving removal levels comparable to the best available advanced wastewater treatment technologies while achieving additional benefits. The recovery and beneficial reuse of wastewater and its nutrient resources through crop production, as well as wastewater treatment and reclamation, allow land treatment systems to accomplish far more than most conventional treatment and discharge alternatives.

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146. Smith & Van Rooyen, supra note 145, at 1-2.
147. Id. at 5-7.
149. Id. at 934.
Whenever States insist upon placing unnecessarily stringent preapplication treatment requirements upon land treatment, such as requiring EPA secondary effluent quality in all cases prior to application on the land, the unnecessary wastewater treatment facilities will not be funded by EPA.150

The decision was challenged by the president of the Water Pollution Control Federation, who questioned the safety of land disposal and emphasized the need for further research on the health hazards.151

In industrial use few laws deal directly with water conservation by in-plant recycling. Soviet regulations mandate the adoption of recirculating water supply systems at the planning stage of industrial enterprises and prohibit discharge of effluent that might be reused.152 In Japan, recycling appears to be on a voluntary basis. The industrial reuse rate there has reportedly reached almost sixty-five percent, although a large part of the water reused is from cooling or air-conditioning facilities; relatively little is from manufacturing and washing processes.153 In West Germany there are no legal restrictions on water supply to industry or requirements to recycle. Industries are led to consider recycling because of governmentally imposed effluent charges and the possibility of saving chemicals or other product solids.154 A modern plating works using the ion exchange method for separation of liquid and solids can recycle ninety-five percent of water used. Generally, the rate of reuse achieved in West Germany (mostly for cooling) is some eighty-three percent in steel mills and eighty-seven percent in coal mining and coal processing.155

Israel has taken a different approach. Norms for water consumption have been set by the Water Commissioner, in cooperation with industry engineers, for each type of product; these levels are published as amendments to the Water Law. The restricted water allocation, combined with incremental water rates, forces industries to recycle water and to use closed cycle cooling. The norms are changed in accordance with new developments in technology. In the dairy industry, for example, 3.5 liters of water were required in 1964 to process one

150. Id.
151. See [1977] 8 ENVIR. REP. (BNA) 906 (Oct. 3).
152. Kolbasov, Legislation on Water Use in the Soviet Union in WATER IN THE SOVIET UNION, supra note 17, at 119. These regulations apply where there is appropriate technico-economic justification. Id.
154. Expert Group Report, supra note 104, at 23; remarks of A. Albrecht, delegate from West Germany, in discussion at the Expert Group Meeting, Nov. 11-22, 1974 (see note 104 supra).
155. Figures given by A. Albrecht in discussion at the Expert Group Meeting, Nov. 11-22, 1974 (see note 104 supra).
liter of milk. This amount was reduced by 1969 to 2.3 liters, by 1973 to 1.7 liters, with a target of 1.45 liters in 1977. Similar reductions have been achieved in other industries. Between 1962 and 1975, water consumption per 1,000 Israeli pounds of production at 1975 prices was reduced by c.147 to 55 cu. m. in mining and quarrying, from 15 to 8 cu.m. in textiles, from c. 64 to 16 cu.m. in paper production, and from 28 to 10 cu.m. in chemicals.

F. Conjunctive Use

Where an interrelationship between ground and surface waters can be identified, unified treatment and exploitation of these waters as a common pool with interchangeable uses may replace separate management of the two sources. The benefits of conjunctive use are many. Integrated supplies of water can be more evenly and reliably distributed. There is less waste and loss in transit, as floodwaters and other surplus flows can be controlled and stored more effectively. Large dams, impoundments, and long distance diversions of surface waters may not be necessary. Hence, because of the less expensive and often nonstructural means of augmenting supply, a lower capital investment is required.

 Conjunctive use also provides advantages due to the potential for alternation of water supplies. Surface waters can be used at one season of the year and ground water at another; ground water can be deliberately overdrawn during periods of low surface flow and replenished later. In one area of high evaporation loss, planners envision the deliberate but temporary exploitation of local ground waters beyond their long-term yield until surface storage is completed. Then surface flows and storage would be used while the aquifer recovers. Eventually, surface storage and ground water would be alternated, the former for sup-

156. Arlosoroff, supra note 58, at 29.
157. Id. at 30 (table 2).
159. TAHAL, supra note 158, at 2; A. Wiener, supra note 158, at 4.
160. For a more complete discussion of underground storage of water, see Gleason, Water Projects Go Underground, 5 ECOLOGY L.Q. 626-29 (1976), and sources cited therein.
ply and aquifer recharge, the latter for supplementary use. Such interchanges are typical of conjunctive use projects and are especially valuable in agriculture. Water can be delivered with great flexibility according to crop needs, at the precise time, and in the precise amounts required. It is ground water storage which gives the desired element of reliability and lessens evaporation loss. Moreover, unlike surface reservoirs, aquifers usually take little or no land out of production when used as storage basins. The value of conjunctive use was amply demonstrated during the recent drought in California. Areas where conjunctive use was practiced and where the water supplies of wet years had been stored underground for future withdrawal fared well. So did individual farmers who had wells and were able to switch to ground water as the drought developed and their surface supplies dwindled.

A negative aspect of conjunctive use is that it often involves the blending of waters of different quality and characteristics; it may introduce pollutants into aquifers. Surface flows may be significantly changed in quantity and timing, and the result may be damaging to users downstream and to the environment. The storage of surplus surface flows underground, for example, may eliminate some areas of marshy vegetation that have value as wildlife habitat or pasture. Conjunctive use is an artificial intervention in a natural process, and its long-term effects on a water resources system are unknown.

Despite these uncertainties, conjunctive use is now fully operational in some parts of the world and in experimental use in many others. These areas vary widely in climatic, hydrological, and hydrogeological conditions, in established patterns of water use, in primary source of supply (surface or ground water), and in the purposes for which the projects were devised, whether agricultural, municipal, or industrial. They include Indonesia, parts of India and Pakistan, northwestern Australia, Iran, Israel, the U.S.S.R., Sweden, the United Kingdom, Hungary, and several states in the United States. For instance, projects have been established in Iran near Teheran in the Varamin Plain, which is underlain by a vast natural reservoir of ground water. The project is designed to supplement river flow in dry years by...
overpumping, and to replenish ground water in normal and wet years by recharge. The combined supply may be augmented from external sources by the conveyance of treated wastewater from the municipal sewage system of Teheran.165

In one Indian irrigation scheme, surface waters have been combined with tube wells in such a way that the canal waters are applied to narrow strips instead of huge blocks of land. The infiltration from the strips provides a steady yield for shallow tube wells that water the belt between the strips, while deeper tube wells act as drains. The combination of surface and ground water helps minimize evaporation loss and prevent waterlogging and salinization.166 In the U.S.S.R. conjunctive use of ground and surface water has proved to be of great practical value where ephemeral streams flow in narrow ravines. Subsurface dams prevent ground water outflow and surface dams accumulate intermittent surface runoff. Ground water is then withdrawn by transverse galleries or by collector wells.167 In Israel, many of the techniques of conjunctive use have been employed for years on a nationwide scale. The greater part of the country's water supply, both underground and surface, is piped into and distributed from a national grid.168 Indonesia, which is only beginning to develop ground water, has prepared a detailed scheme for the integration of ground and surface water, together with proposals for conjunctive administration.169

The different technical aspects of conjunctive use have correspondingly different implications for water law and administration. Integration of the use of individual wells with that of nearby surface waters is usually a matter of determining or redetermining individual rights in terms of quantity, duration, and manner of use. For greatest efficiency and maximum benefit, it should be possible for users to transfer freely from surface to ground water and vice-versa, and to do so for a period of years as circumstances dictate, without losing the right to the previous source of supply. It should also be possible for the administration to modify the amount of water granted when switching

166. High ground water levels cause increased salinity and waterlogging. By carefully scheduling irrigations so that excessive amounts of water are not applied, and providing adequate drainage, farmers can fight salinity and waterlogging. Hatfield, Joint Management of Ground and Surface Water, supra note 161, at 87. For a description of a Pakistani scheme to reduce soil salinity in the Indus River Valley, see Hatfield, Problem Areas, supra note 161, at 98.
168. Arlosoroff, supra note 58, at 6-7.
169. Indonesia, Joint Management, supra note 164, at 183 (fig. 3).
from a surface supply, which usually includes a percentage for seepage and evaporation, to a ground water supply and vice-versa. However, legal regimes that prohibit transfer and rigidly limit the retention of unused rights may make it difficult to coordinate the use of ground and surface waters with any degree of flexibility.

In the Western United States, conjunctive use has been introduced in several areas through programs of individual exchange and purchase of rights. Quite often this has come about only during a crisis. As surface waters have become fully appropriated and inadequate for overall needs, wells have been sunk to tap the underflow of rivers, thereby enabling ground water users to siphon off water to the detriment of holders of existing surface rights. To remedy this situation, New Mexico began in the 1950's to make the approval of new ground water appropriation applications in the Rio Grande valley contingent upon the applicant's ability to offset the effect of his pumping on the flow of the river. This scheme has been accomplished by acquiring surface water rights and retiring them from use in graduated amounts and in strict time sequence, according to the so-called Theis formula for balancing the surface and ground water components. Eventually, the effect of pumping on the surface flow has been entirely compensated by the surrender of rights to an equivalent amount of surface water.

Colorado's Water Right Determination and Administration Act of 1969 offers a variety of alternatives for the achievement of conjunctive use through ground and surface water integration by individual users: the use of wells as alternate points of diversion for surface rights; the provision of a substitute supply to a downstream senior appropriator, either by installing wells or by purchasing and releasing reservoir water for the senior appropriator's use; or the development of a plan for augmentation, which may include pooling water resources and exchange projects. In effect, the Colorado Act subordinates ground water use to the existing system of surface rights. It leaves im-

171. When all water from the source is appropriated, the state engineer can approve new appropriation applications only upon making a finding that the new appropriation would not impair existing water rights from the source. N.M. REV. STAT. § 75-11-3(E) (Supp. 1975). Pursuant to this requirement, the state engineer promulgated regulations requiring the retirement of surface rights before the finding could be made. These regulations have been held to be within the power of the state engineer to promulgate. City of Albuquerque v. Reynolds, 71 N.M. 428, 379 P.2d 73 (1963).
172. See generally Theis, The Effect of a Well on the Flow of a Nearby Stream, 22 TRANS. AMER. GEOPHYS. UNION 734-38 (1941); Flint, supra note 164, at 545.
174. Id. § 37-92-301(3)(b) (1973).
176. Id. § 37-92-103(9).
plementation essentially to private parties and requires the state engineer to exercise the broadest latitude possible in approving supply augmentation plans, consistent with the decisions of state water judges.\(^{177}\) Wyoming law encourages voluntary exchanges as a matter of state policy.\(^{178}\) Any appropriator owning a valid right to surface, reservoir, or ground waters may apply to the state engineer for an exchange "where the source of the appropriation is at times insufficient to fully satisfy such appropriation, or better conservation and utilization of the state's water can be accomplished. . . ."\(^{179}\)

Manipulation of ground and surface waters on a large scale and over a wide area requires management by public entities.\(^{180}\) This aspect of conjunctive use may involve such elements as aquifer recharge,\(^{181}\) flood-flow storage in aquifers,\(^{182}\) creation of barriers to salt water intrusion,\(^{183}\) release of ground water to maintain surface flows or of surface water to maintain ground water levels,\(^{184}\) and the mixing of waters of different characteristics and different quality.\(^{185}\) Some of these operations have been carried out for many years, though as a rule independently and not as part of an overall integration program. Aquifer recharge, for instance, was practiced in Sweden as early as 1890, when a plant was installed for the town of Gothenburg; it was not a widely used technique in Sweden, however, until the 1940s.\(^{186}\)

The public entities that engage in these activities range from municipalities to special purpose districts, regional management units, and national water resources agencies. In Colorado, augmentation plans may be employed by municipalities, water supply entities, water conservancy districts, and irrigation districts for the benefit of all their users.\(^ {187}\) Natural resources districts are authorized to carry out ground water storage in Nebraska.\(^ {188}\)

\(^{177}\) Id. § 37-92-307(7).
\(^{179}\) Id. § 41-5(a).
\(^{180}\) The Israeli National Water Grid, which interconnects the country's principle water resources, makes it possible to convey any surplus of water (occurring in northern Israel) to areas of water deficiency (in central and southern Israel). A. Wiener, supra note 158, at 6. The National Conduit system consists of canals, tunnels, and pressure pipes connecting a number of regional water projects utilizing local water resources. Id. It is hard to imagine such a system being centrally designed and managed by anything but a governmental or quasi-governmental unit.

\(^{181}\) TAHAL, supra note 158, passim; A. Wiener, supra note 158, at 4.
\(^{182}\) TAHAL, supra note 158, at 2; A. Wiener, supra note 158, at 4.
\(^{183}\) A. Wiener, supra note 158, at 8.
\(^{184}\) Id. at 10.
\(^{185}\) Id. at 11; TAHAL, supra note 158, at 5-7.
\(^{188}\) NEB. REV. STAT. § 2-3238 (1977).
tation of water are the responsibility of ground water management districts, which are essentially users' associations. The governing boards of the regional water management districts in Florida are specifically empowered to construct works for ground water storage and aquifer recharge, as well as for aquifer withdrawals for water supply.

In countries that have nationalized all water resources and in which the administration has ample powers to control supplies and carry out projects, the problems of conjunctive use are technical rather than legal. Artificial recharge projects in the U.S.S.R., for example, are planned and coordinated for the whole country by a single entity, the State Committee for Science and Technology of the Council of Ministers of the U.S.S.R. In Israel, as noted above, conjunctive use has been established on a national scale by means of a single water supply system. Israel's water law makes no distinction between ground and surface waters or between types of ground water. The right to use water is not linked to a specific water resource, but only to a specific quantity of water, and the Water Commissioner has authority to change a source of supply at his discretion. Similarly, the administration in Peru was authorized by legislation in 1969 to substitute "one water supply source serving one or more users with another of similar flow and water quality with a view to achieving a more rational or otherwise better use of resources."

This right to substitute raises the question whether a user who receives water from an alternative source may have suffered an infringement of his rights. The Peruvian statute requires the substitute water to be of "similar" quality. The Florida Water Resources Act of 1972 lays particular stress on the requirement that storage or recharge water be of "compatible" quality. On the other hand, the Israeli Supreme Court upheld the power of the Water Commissioner to direct that a user take water from a different source of lower quality, on the ground that the user's right did not extend to water of a specific quality but only to a quality that he could use.

189. KAN. STAT. ANN. §§ 82a-1028(g), (h) (Supp. 1976).
190. FLA. STAT. ANN. §§ 373.087-.103, .106 (West 1974).
191. Sychev & Khordikainen, supra note 167, at 4-5.
192. See text accompanying note 168 supra; see note 180 supra.
194. WATER IN EUROPE, supra note 17, at 112.
196. Id.
197. FLA. STAT. ANN. § 373.087 (West 1974).
There are inherent dangers in some elements of conjunctive management, such as artificial recharge, since ground waters lack the capability of natural recovery from pollution that surface flowing waters possess. It has been estimated in Sweden, for example, that it takes 100 days residence time for infiltrated surface water to correspond in quality to natural ground water, and minor changes could still be observed after 300 days. Aquifer recharge operations, therefore, need to be closely monitored. In Israel, recharging is done under license from the Water Commissioner and full details must be submitted in the license application, which is made available for public examination and is subject to objections by those who may be affected. The main licensee is Mekoroth, the national water authority, and it is required to carry out periodic tests of the effect of its operations on water resources in the area.

Some degree of evaluation of all aspects of a conjunctive use program is essential. New Mexico, for instance, has set provisional limits to its program of balancing ground and surface water withdrawals in the Rio Grande valley. A municipal water supply company was granted a permit in 1972 to appropriate ground water subject to the retirement of surface rights. The permit, however, was strictly limited in amount for the first five years and was issued with the proviso that it might be modified as conditions warranted. Even more important than on-going monitoring and evaluation of conjunctive use are thorough prior investigation and recording of all factors that may be pertinent—social, economic, and legal as well as hydrological and hydrogeological. In an effort to maintain the type of information required, Colorado has established a computerized data bank which contains historic surface runoff and climatological data, characteristics of aquifers, wells, and surface storage, plus records of all water rights adjudication proceedings, surface diversions, and well drilling.

Despite the relatively few guidelines that exist at present to aid in resolving the legal and administrative problems that it may pose, conjunctive use already holds such promise for the conservation and efficient use of water that it has been a major recommendation of many recent conferences and reports. Some of these policy recommenda-

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200. Water in Europe, supra note 17, at 99-100.
201. The Water Commissioner is entitled to discontinue recharging schemes where he finds that the recharging has rendered the water unfit for its intended use. Id. at 100.
204. The International Conference on Water Law and Administration, held at Caracas in Feb. 1976, urged governments to:
tions stress the need for a single, integrated body of law as a starting point for conjunctive use; this is already extant in the Colombian Natural Resources and Environmental Protection Code of 1974, which envisions the conjunctive use of surface, underground, and atmospheric waters within hydrographic basins.\footnote{205}

III

SUMMARY OF TRENDS

Efficiency in use of water resources has become one of the major goals of modern water management. Whereas old water laws gave little expression to conservation and did so only as dictated by local conditions, many contemporary water codes emphasize the importance of enhancing efficient use. The availability of technology that makes significant savings of water possible, and rising demand for water which makes shortages a very real possibility, have accelerated a trend toward centralization of water management under the control of government. Such authority over practically all sources of water, including ground water, provides the greatest potential for effective and economic use of water from a general welfare perspective by recognizing and monitoring wasteful practices that have been previously beyond the reach of regulation.

Along with gathering all waters under administrative controls there has been a consolidation of the administrative structure itself. Water administration has become resource-oriented instead of use-oriented, as separate administrative departments in charge of particular

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water uses, have been united in one agency or ministry.\textsuperscript{206} Consolidation reaches its logical extreme in so-called conjunctive management of waters. This method transcends the separate administration of different types of water, surface and underground, and substitutes for it a truly integrated system of water law under which rights to a common "pool" may be assigned and in which shortages of surface water can be compensated by the use of ground water and vice versa.

Modern water legislation not only subjects all waters to a single regulatory structure, but also includes all uses, whether old or new, under that system. This integration can be accomplished by cancelling old rights and requiring all uses to comply with new requirements, but such a drastic, though effective, solution has not been widely adopted. More commonly, users under older systems are given a period of time to conform to the new. Uniformity will eventually be achieved, but the applications of former rights holders can as a rule be refused only if the public interest demands it. This more or less smooth conversion of old rights into new ones obviates the perpetuation of system of rights that have become out-of-date and wasteful.

As well as making transfer from one system to another as smooth as possible, the newer legislation relaxes the constraints on transfer of water from one use or place to another use or place. Usually, the approval of the administration is required, as in the Iranian and Peruvian codes and in the law of the State of Washington.\textsuperscript{207} Complete freedom of transfer, subject only to market fluctuations, might be the most effective method of promoting economical use of water, but for various political and social reasons it remains chiefly a recommendation. Another feature in the newer water codes that fosters economical and effective use of water is the limitation of such use to a definite period of time. The length of time has not been uniform, but perhaps should not be shorter than twenty-five years, as advocated in some modern codes. By setting time limits on uses, past mistakes can be corrected and water uses fitted more easily into a flexible general scheme.

Finally, the amount of water that may be used becomes precisely determined and geared to individual needs and overall planning. Pricing is one, if not the principal, limitation on the quantity of water used if no volumetric ceiling is imposed. Even for domestic purposes, there is a trend away from free or inexpensive water toward a progressive rate structure based on metering of the supply. This pricing system has proven very effective in reducing municipal water demand, and, in combination with effluent charges, has forced industries to reduce direct consumption and recycle a major portion of the water used. The

\textsuperscript{206} See, e.g., Alaska Water Use Act, ALASKA STAT. §§ 46.15.010-270 (1978).
\textsuperscript{207} MOSLEM COUNTRIES, supra note 2, at 77 (Iran); D. DAINES & G. FALCONI H, supra note 17, at 170 (Peru); WASH. REV. CODE ANN. § 90.03.380 (1962).
ultimate in water reclamation is the reuse of purified effluent for domestic purposes and for the irrigation of fruits and vegetables eaten fresh. The law is beginning, in several water-short areas of the world, to provide for such reuse, which is expected to become quite common by the end of the century. At present, however, wastewater continues to pose potential health hazards if ingested, even when it is treated to the highest standards and with the best available techniques. Experts do not recommend this except in countries with a level of technology adequate to operate and monitor the very advanced treatment required.

It is evident that notions of efficient use and conservation of water will become increasingly integrated into the laws of nations around the world. The forces that have impelled a departure from earlier legal rules will undoubtedly intensify. Faced with burgeoning demands for water resources, societies must look to innovative and productive legal systems to ensure adequate supplies in the future.