WATER RIGHTS AND ASSESSMENTS

(Proposals involving Antarctic Icebergs for the
Colorado River Basin, California, Mexico and other arid lands)

John L. Hult

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The Rand Corporation
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INTRODUCTION

During the next few decades as global population inexorably soars to levels that will tax worldwide resources for providing subsistence, it behooves mankind to take every opportunity to prepare for extracting from the environment the maximum food and renewable subsistence that can be produced. There will still remain an important problem of distribution of the food and necessities to the starving and most needy through appropriate exchange. However, this should not excuse the United States and other more developed or more wealthy countries from developing the technology and means for producing more food and global necessities than we need for ourselves, in order to help in the survival and development of less developed areas of the world. Thus all suitable land resources will need to be converted to full production.

Some of the potentially more productive land lacking only good quality inexpensive water is found in the Colorado River basin, Southern California, and Northwest Mexico. Recent studies of the feasibility of importing Antarctic iceberg water indicate promise for obtaining this water at much less expense than for desalting or long range interbasin transfer.[1,2,3] It could be obtained near the coast for less than $30 per acre foot, and should therefore become attractive for irrigating high value crops. However, if its use is to be viable, many problems relative to water rights and the allocation of costs must be made compatible with established institutions, tranditional subsidization, and vested systems. The complexity of the problem makes it very difficult to conceive of acceptable general principles for water rights and cost allocations that could be applied simply and unambiguously. However, such principles need to be promulgated if the land use development is to evolve gracefully to the full potential needed to support the burgeoning global population. It is with this objective that the proposed principles are advanced in this paper and are illustrated for the Colorado River basin, California, and Northwest Mexico to demonstrate the exciting possibilities for Antarctic iceberg resources used in accordance with the proposed principles. The same principles could be applied in much of the rest of the world where Antarctic icebergs might

provide the water needed for development, and a very cursory illustration for the Jordan basin is provided, however this paper focuses the illustrations on the limited area previously indicated which still involves the interaction of a rich mixture of heterogeneous jurisdictions including international situations and regions in various stages of development.

WATER RIGHTS AND ASSESSMENT PRINCIPLES

The early settlement of the Eastern United States adopted the riparian principles of water rights from English common law practice which seemed well suited to the abundant stream and run-off water resources of the region. However, in the development of Western United States where the water resources were much more limited, the prior appropriation doctrine from old Spanish law received greater acceptance and is still the principal criterion for establishing water rights in most situations. Under the prior appropriation doctrine, the senior, or earlier beneficial use of water within a priority class of use would have first right to its established use. A junior or later use would be first to accommodate deficiencies that may develop in the water resources. Thus an earlier water use could perpetuate its rights as long as they were not abandoned or bumped by a superior priority even though this use might not provide the greatest benefits from the water resources.

The rapidly changing global demand for resources and the concomitant water needs as well as changing water supply opportunities suggest that more flexible and adaptable principles of water rights are needed if orderly and rapid adjustment to the changing situation is to be achieved. New principles of water rights and assessments are therefore proposed:

- *The unrestricted, nondiscriminatory rights of access to water anywhere subject only to appropriate notice for accommodation and the obligation for the prorated assessments.*

The water resources anywhere would be augmented by acceptable means at minimum total cost to the participating system over the programmed use to meet the demand, and the access costs would be prorated between all users according to the consequent benefits (foregone or derived). Priorities and reserved uses would be decided by economics subject only to antitrust actions to prevent the manipulating of supply or demand at public expense by special economic interests. The access price of water to users would include factors for water quality, power head, natural losses (evaporation,

seepage, etc.), and miscellaneous associated considerations such as compensation for easement losses in tax revenue. Common uses such as for recreation or fish and wildlife benefits would pay their prorated share of the costs. This general explanation of the proposed principles for water rights and assessments still leaves many important questions unresolved. Some of these questions and suggested alternative ways of handling them are treated in the illustrative configuration opportunities that follow. The illustrated water *demands* are adapted from references 4 and 5 and are not meant to reflect the influence of more recent markets or the opportunities to obtain less expensive iceberg water. The illustrations are not refined to depict accurate demands or costs. They serve merely to illustrate the opportunities offered by iceberg water and new principles of water rights and assessments.

The California State Water Project

The California water plan as described in reference 5, partitions the state into 11 hydrologic areas. The illustration involving iceberg-water augmentation to the state water project concerns 9 of the hydrologic areas and excludes only the North Coastal area and the North Lahontan area which have water sheds draining away from the central basin. The 9 hydrologic areas involved in the illustration all participate in the use of water from the state water project and could therefore be influenced by any water augmentation and the adoption of new rights and assessment principles. The projected net water demands for the 9 hydrologic areas by 2020 are estimated[5] to be about 33 million acre feet per year (MAFY) from central valley sources and about 5 MAFY are acquired from the Colorado River and other sources outside of the central valley. The projected water demand without significant agricultural increases exceeds the dependable water supplies by more than 5 MAFY. The world food demand pressures during the coming decades are likely to induce agricultural production increases that will greatly increase the demand for water augmentation at the prices for which water from icebergs can be offered. The greatest shortages are likely to appear in the San Joaquin and Tulare Basin areas especially in Kern County, and in the Colorado Desert and South Coastal areas.

The State Water Project plans are designed for an eventual lift of about 2.5 MAFY from the central valley over the mountains to Southern California. Icebergs could be brought to deep water off the coast of Pt. Mugu and the water could be conveyed up the Santa Clara valley into suitable reservoirs formed in the mountain tributaries to provide a substitute for state project water to Southern California. The California aqueduct water (2.5 MAFY) planned for Southern California could then be diverted to Kern County. If even more water was needed in the Southern end of the central valley, the mountain crossing portion of the California aqueduct could be reversed with up to 2.5 MAFY of iceberg water added to the Tulare Basin from the south. It should be possible to recover most of the water lifting energy so as to keep the pumping energy losses to less than the equivalent of 1000 ft in the reverse operations.

If the California aqueduct demand exceeds the reliable supply from the Delta, augmentation with iceberg water also could be made from deep water in the vicinity of Monterey Bay to the San Luis Reservoir. A small augmentation of iceberg water could also be made near San Luis Obispo to obviate the need for the planned Coastal Branch of the state water project. These three augmentations totaling 3 to 10 MAFY could satisfy any of the foreseeable deficiencies of the State Water Project and accommodate any presently conceived growth in demand north of Los Angeles. However, it may be difficult to use the additional water for agricultural purposes if the costs are not prorated fairly over all water users. For example, State project water delivered to Kern County would have a price of about $20 per AF (slightly more than $10 for transportation charge and slightly less than $10 for the Delta charge). To this price must be added the costs of local distribution and irrigation with the water. If neighboring farms obtain their water essentially "free" (from natural run off or underground) except for local distribution and irrigation costs, farms paying the full costs of the state project water would be unable to compete with the "free" water farms. Furthermore, all the water users consume water from the central valley pool, and any augmentation costs required to maintain the adequacy of the pool should be prorated over all the water use from the pool.

As a more specific hypothetical illustration, assume that the total dependable water supply without augmentation to the central valley and state

water project is 27.4 MAFY, and the demand is 33.4 MAFY. The demand could be satisfied with an augmentation of 6 MAFY of iceberg water and if the total augmentation cost is $200 million per year the prorated cost of the augmentation would be $6 per AF *against every acre foot of water consumed from the central valley pool*. This would increase the price of state project water to Kern County to $26 per AF. If 3.4 MAFY of state project water are used in the Tulare Basin at $26 per AF, this would cost $88 million per year, which if prorated over 9 MAFY total consumption in the Tulare Basin including the $6 per AF assessment for the other water drawn from the central valley pool, would amount to a charge of $13.6 per AF for all the water used in the Tulare Basin regardless of source.

The illustrated proration of costs would equalize the water costs in any area, would permit unrestricted, nondiscriminatory rights of access to water, and would enable graceful evolutionary change and growth in the use of water. The total cost to the original users of the natural water supply would increase when augmentation became necessary, but this may be a small price to pay for the unfettered and uncontested access to good quality water. Any detailed cost assessments would have to take into account the differences in costs of local distribution and in quality value of the water; also the energy differences associated with different delivery altitudes or pressures should be taken into account to compensate for power foregone with downstream use or required for upstream augmentation.

The problem of cost assessment for users who may wish to tap the augmentation line from the iceberg to the inland reservoir or California aqueduct is one to be worked out locally. However, if the augmentation would replace a westward branch from the aqueduct as might be the case for a small augmentation near San Luis Obispo, it would only seem appropriate for the users of the iceberg water to absorb all the costs without any assessment from the state water project from which they would not benefit. On the other hand, any users that might tap the two-way augmentation line from Monterey Bay to the San Luis Reservoir should probably be assessed their share of the inland transportation costs and their proration of the total Delta and augmentation costs per unit of water used. A similar situation would probably apply to Ventura County users who might wish to tap the inland

augmentation from Pt. Mugu.

Colorado River Augmentation

The partition of the rights to Colorado river water was made when it seemed that the supply would be adequate to allocate 7.5 MAFY to the upper basin (above Lee Ferry), 7.5 MAFY to the lower basin in the United States, and still satisfy a treaty commitment of delivering 1.5 MAFY to Mexico at the border. It now appears that the water resources of the Colorado River Basin have been over committed, and that if all the United States allocations are fully exercised there will not be enough water to satisfy the Mexican treaty commitment. The Federal Government has therefore accepted the obligation to augment the Colorado River to satisfy our treaty requirements which action may become necessary by the mid 1980s. The federal obligation for augmentation could be satisfied by delivering 1.5 MAFY of good quality water at the border; however, the growing demands of the upper and lower basins in the United States will support additional augmentation which might be accomplished most efficiently in a combined augmentation plan. The upper basin will have growing water demands for processing energy resources in the region, and the lower basin demands for more and better quality water for agricultural purposes are likely to be especially voracious. The present commitments withdraw in excess of 5 MAFY near the Mexican border primarily for agriculture in California, Mexico, and Arizona. Any augmentation plan that could directly supply these commitments would permit release and exchange of 5 MAFY of Colorado River water for additional up-stream uses. In addition, the municipal and industrial (M&I) growth, ground water overdraft, and new agriculture demands in areas near the border and the Colorado River could easily double or triple these demands by the end of the century. Thus it may be desirable to plan for an augmentation to the Colorado River water supply near the Mexican border of as much as 10 MAFY or more.

There are many possible physical configurations of plans for providing the above augmentations. However, if political and environmental constraints are not considered, several deep water terminals for icebergs near shore between San Clemente and La Jolla, California, and near Descanso, Baja, should be considered. There are a number of potentially attractive large reservoir

sites near the border on the Pacific slopes of California and Baja, that could serve for supply storage for water delivery over the mountains near the border for Colorado River augmentation. The reservoirs could also satisfy a growing demand for M&I and agricultural water for the coastal plains in San Diego County and Baja. If the western canal diversions from the Colorado River are modified to be able to pump in either direction, the Colorado River reservoirs could also be used to provide backup storage capacity for the iceberg supply system.

The augmentation from the Pacific will require a lift of more than 1000 m to cross the mountains, but it should be possible to recover 3/4 of this energy in the fall to the lowlands so as to generate 2000 to 5000 MW of power for inland use. The reservoir and supply system could be arranged to provide the equivalent of pump storage for high peak power capacity. The basic system energy could be derived from atomic power plants near the coast that use iceberg water for cooling and supply the lifting energy for the water.

If there is a significant increase in the irrigation in Imperial Valley there may be an increase in drainage to Salton Sea. In order to control the level of the sea it would then be necessary to pump out some of the brine (a drain channel to Laguna Salada might prove attractive for eventual salt recovery from evaporation of the brine). If more than about 10 percent of the input to Salton Sea can be pumped out (less than 90 percent evaporated), the salinity can be brought under control so that marine life could thrive and it might be possible to introduce large scale commercial mariculture (perhaps in the central portion of the Sea) without interfering with the enhanced fishing and recreational opportunities that would be available. Control and use of the Salton Sea in the above manner could make it an extremely valuable asset rather than a worrisome consequence of Imperial Valley irrigation.

In order to illustrate the proposed principles and an interpretation of the assessments that might be involved, a hypothetical illustration of Colorado River augmentation will be considered. Assume a total natural run off from the Colorado River basin of 16 MAFY including 0.8 MAFY from the Gila River basin. Also assume a combined augmentation of 8 MAFY from

several iceberg terminals on the Pacific Coast at a total amortized augmentation cost of $300 million per year. Then every user (state) of augmented Colorado River water would be assessed an average of $12.50 for each acre foot diverted from reaching the Colorado River at the Mexican border. The prices would be adjusted for salinity, natural evaporation and losses, and common power lost from the point of diversion to the Mexican border. Credit according to quantity and salinity would be given for any returns reaching the Colorado at the Mexican border. For example, each acre foot diverted for agriculture in the upper Colorado might involve a return of 0.3 AF and natural losses from evaporation and seepage so as to produce an effective diversion of only 0.5 AF from the river at the Mexican border. The assessment for this use would be based on the effective diversion, salinity, and power loss referred to the river at the border. The salinity factor might be taken into account by adjusting the prices according to some linear relationship such as $P = P_o(1 - S/1600)$, where the pure water price, P_o, is reduced by the salinity, S, in parts per million. As a further example, if less than 1/4 of the Gila River Basin run off naturally reaches the Colorado River, the Arizona assessment based on the equivalent effective diversion at the Colorado River would be for less than 1/4 of the diversion in the upper Gila Basin.

The augmentation aqueducts from the Pacific Coast to the Colorado River should be considered as artifical tributaries of the Colorado and therefore available for diversion of water from the Colorado. A new user diverting from the augmentation aqueduct should be assessed for his water use according to the same formula used for others sharing the augmented Colorado. In addition, he should bear the added transportation costs required in the agumentation aqueduct to accommodate his water demands. Established users such as the Imperial Irrigation District ought not be required to pay for additional transportation costs. Modification and supplementation to the All American Canal to take a reverse flow toward the Colorado would make up about 1/2 of the augmentation aqueduct length, but these costs could legitimately be prorated over all the augmented Colorado River users. The Imperial Irrigation District could still be obligated to retrieve the original capital investment for the All American Canal.

The iceberg augmentation water would be higher priced than the original Colorado River water because of its much lower salinity. However, this would permit use of less water to achieve equivalent productivity and less costly irrigation practice and facilities. The irrigated acreage draining to the Salton Sea could probably be doubled without increasing the draining flow into the Salton Sea.

Mexico might choose to participate as she desires. She might elect to take the treaty commitment (1.5 MAFY) free and pay the full augmentation costs for any added quantities desired, or she might wish to participate in the same way as the states across the border. For the previously illustrated augmentation, full and equal participation in the augmentation costs would be the least costly for Mexican use of augmentation water exceeding about 50 percent of the treatly commitment, i.e., a total withdrawal greater than 2.25 MAFY.

In any operational application of the principles herein proposed, it would be necessary to devise some means of coordinating and programming the demands of all potential users when long lead times are required for changing augmentation, and the individual demands are sensitive to the total demand and consequent price of the water. A suggested procedure might be to reprogram each year the demands for the next ten years based on the requests from all potential users with the proviso that there will be no obligation to try to accommodate or release from commitment and change in the yearly quota exceeding 10 percent of the previous highest requested demand for any specific year or the demand programmed at the 10 year advanced entry for that year. This would permit the system to evolve more smoothly and permit better forecasts of the water rates required for augmentation to be fed back as a factor in determining the demand.

Independent Mexican Demands

The remainder of Baja south of Ensenada is deficient in natural water resources and could not very well be associated with the Colorado River augmentation. The independent use of iceberg resources should still be attractive even though there are insignificant natural water resources to dilute the cost of augmentation.

Sonora, Mexico, may have a more urgent need for iceberg water resources. Augmentation to established irrigation systems might become especially attractive where natural water resources are proving to be deficient and where land for agricultural expansion is readily available. Icebergs could be brought to the southern end of Isla Tiburón and a large reservoir might be formed with dams between the island and the mainland to provide an excellent augmentation supply for reliably irrigating a large portion of the potentially most productive land in Sonora.

Applications to Other Situations

The basic principles herein proposed for the unrestricted, non-discriminatory rights of access to water anywhere have previously been proposed in reference (2) for extension to the annual yield of Antarctic icebergs. This could be accomplished in conjunction with a sensing system such as Earth Resources Technology Satellites (ERTS) to provide a monitoring and claiming service and the information needed for an annual auction of the available icebergs.

The use of iceberg water resources is potentially attractive in many other areas of the world that might be epitomized with outlined examples from the Middle East. Icebergs could be floated to the eastern end of the Mediterranean where the fresh water could be used to augment the upper Jordan, greatly increase agricultural production, and flush out Lake Tiberius so as to freshen its waters and allow its use as a supply reservoir for greatly increasing irrigation of the lower Jordan basin. The increased input to the Dead Sea would allow pumping brine out for evaporation recovery of the salts in some unused dessert area near a seaport for exporting the salts of value. This flushing of the Dead Sea would eventually return it to a live condition that could support many mariculture and recreational services.

Icebergs could be brought in through the Indian Ocean to the Arabian Peninsula from the Gulf of Oman, the Arabian Sea, and the Gulf of Aden. A terminal could also be made near Djibouti for inland augmentation of the Awash Basin and the development of irrigation of much of Ethiopia northward of the Ahmar Mountains to the Red Sea. If the brief deep water

interruptions in the Southern Red Sea are cleared, full-sized icebergs could be brought into the Red Sea. From terminals near Jiddah much of the Red Sea coastal plains and northern basement area of Saudi Arabia could be developed for productive irrigated agriculture. The Nile River could be augmented from the northern Red Sea and much more of the Nile Basin and eastern Egypt could be developed for irrigated production. From the Gulf of Aqaba much of Southern Jordan, Israel and the Sinai peninsula could benefit from iceberg water. Thus the arid Middle East might eventually become one of the largest northern hemisphere users of Antarctic iceberg resources. In addition, Australia and other southern hemisphere arid regions should especially find the Antarctic iceberg resources attractive. In most of these potential applications, particularly when augmentation of natural or existing water supply systems is involved, iceberg water resources could be introduced much more easily and effectively under the water rights and assessment principles herein proposed. Also, the water usage could evolve more gracefully, and greater economic benefits could be derived from this valuable resource with the application of the proposed principles.

SUMMARY AND INTERPRETATIONS

The use of Antarctic icebergs as a fresh water resource appears particularly attractive for augmenting the world food production to alleviate the stress of the forthcoming world population crunch. However, viable plans for the timely use of iceberg resources must be made compatible with established water use practices. The adoption of the proposed water rights and assessment principles providing unrestricted, nondiscriminatory access to water anywhere would greatly facilitate the initiation and evolution of the use of water for greatest world-wide economic benefit. It would relieve the unfair competition and subsidy from established water users and facilitate greater benefits from water use of natural indigenous water supplies as well as imported augmentations. It would recognize the value of water quality and offer many opportunities to improve the quality of water supplies and to rejuvinate dead or dying water bodies. It would make particularly attractive the augmentation of deficient natural water supplies, and suggests versatile arrangements of reservoirs and two-way conveyance systems to provide greater evolutionary freedom and the ability to take advantage of future opportunities. It would unshackle much of the world from the development constraints of indigenous water supplies, and enable the gainful employment of the world's largest reserves of fresh water as the Antarctic icebergs otherwise waste away to the sea.

The proposed principles need to be recognized and adopted so that the potential user demand for good quality fresh water can be expressed and the timely world-wide benefits of Antarctic iceberg resources can be exploited.

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