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Salt Problem in the Colorado River

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SALT PROBLEM IN THE COLORADO RIVER*

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My purpose is to bring to this Symposium background information about the sources of salt load in the Colorado River and what is being done to ameliorate the problem.

The process of salt accumulating in rivers of arid regions from natural solution of minerals and from irrigation processes is the age-old nemesis of those peoples who must irrigate to survive in the arid zone. Man's ability to control salinization of irrigated lands and to control salt concentration of rivers downstream from irrigated valleys has been tested since the beginning of recorded history. He has had some successes; many failures. The successes in controlling salinization of irrigated lands have come about through scientific and technological advances. The failures have generally resulted from man's inability to apply the knowledge and processes available to him. Most scientific experts agree that salinization need not occur in irrigated lands if available management techniques are applied. This, however, implies substantial capital investment as well as substantial transfer of technology and the incentive to adopt new technology.

The problem we are discussing here today is not entirely one of salinization control, but, rather, it is a problem of controlling the concentration of inorganic salts in the water supply.

The Colorado River is the life blood for a large region of the southwestern United States. Rising in Colorado, it is almost completely controlled through its 1400-mile journey to the Gulf of California. With a combined storage capacity of five times the average annual runoff, annual releases from major storage reservoirs on the river are predictable within one million acre-feet over a two or three year period.

Water of the river is used and reused—there is not enough to supply the demand. To illustrate, annual water releases at Hoover Dam are approximately 8.25 million acre-feet (maf) annually. At the same time, total water deliveries amount to 9.8 maf: Mexico, 1.5 maf; California, 5.2 maf; Nevada, 0.1 maf; Arizona, 1.7 maf; and

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estimated evapotranspiration from river and reservoirs, 1.3 maf.[1] This means that 1.55 maf is reused water accounted for by return flow back into the system from a previous use.

Over the years there has been a slowly rising increase in the concentration of inorganic mineral salts in the river. Users in the Lower Basin may be suffering injuries because of this fact. There is an estimate which is sometimes cited that each 1 ppm increase in salt results in damages of $230,000 to combined agriculture, industry, and municipal users.[2] At current concentrations of salt compared to ideal, a penalty of $16 million per year is estimated to be suffered by water users in the basin. That estimate is projected to $51 million per year by 2010.[3] Although the reliability and accuracy of the foregoing damage estimates may be questioned, there is no doubt that further increases in salt concentration will cause injuries in the form of reduced crop yields, increased water treatment costs, etc. These estimates of damage do not include damage occurring in Mexico or damage to the fishery in Salton Sea.

The salt load in the Colorado at Imperial Dam is about 10 million tons annually.[4] If present concentration levels are to be kept unchanged in the Lower Basin, as now proposed by the Environmental Protection Agency with state government concurrence,[5] then 2.5 million tons of salt must be removed from the Colorado River each year. If not removed, then an equivalent amount of salt must be prevented from entering the river system along its entire length.

Salts in the river originate from several sources: [6]

Natural	47%
Irrigation	37%
Evaporation	12%
Export of Pristine Waters	3%
Municipal/Industrial Waste	1%

The nature of these sources and their control will be discussed later.

At the present time, headwaters of the Colorado River in Colorado

1. U.S. Dep't of the Interior, Southwest Energy Study (1972).
2. U.S. Dep't of the Interior, Water for Energy in the Upper Colorado River Basin (1974).
3. J. Maletic, Current Approaches and Alternatives to Salinity Management in the Colorado River Basin (Proceedings of the 15th Ann. Western Resources Conf., U. Colo. at Boulder, July 1973).
4. Bureau of Reclamation, U.S. Dep't of the Interior, Quality of Water: Colorado River Basin (Progress Rep. No. 6, Jan. 1973).
5. Resolution of the Conferees of the Colorado River Basin States, Feb. 17, 1972, in Minutes of the Pacific Southwest Inter-Agency Committee, 74-1 Meeting, app. B (1974).
6. U.S. Dep't of the Interior, Colorado River Water Quality Improvement Program (1972).

contain no more than 50 ppm of inorganic salts, but, by the time the river reaches Imperial Dam, it has collected a concentration of 865 ppm (1973).[7] If no action is taken to prevent increases which will occur as a result of planned water development projects, the concentration at Imperial Dam by year 2000 will be 1200 ppm.[8]

Now, this degradation of the Colorado River is not in accord with United States national policy on clean water. Through action by the Congress over a decade culminating in the Clean Water Restoration Act of 1966,[9] the people have declared that degradation of water quality cannot be tolerated and that already degraded water shall be cleaned up. U.S. policy on "clean water" really began with the Water Quality Act of 1965[10] and is currently expressed in the amendment to that Act passed by Congress in 1972.[11] We have set out to protect downstream users from improper degradation of their water supply. By 1983, we expect all waters of the United States to be of such quality as to allow its use for both fishery and body contact recreation. By 1985 we expect that there will be no pollutants discharged into the waters of the country.[12] Wastewater treatment will be depended upon heavily to enable us to meet these goals. The best practicable treatment of all wastewaters will be required by 1977, and, by 1985, the best available treatment processes will be required for all waste effluent.[13] Discharge permits which specify the allowable amounts of all polluting constituents are now being required of most effluent dischargers.[14] Furthermore, municipal and industrial dischargers must monitor their own waste discharge and report to the water quality control authorities.[15]

With regard to salinity as a pollutant, the United States has faced a dilemma as to whether or not it can be considered a controllable pollutant. In 1966, westerners felt that inorganic mineral salts should not be considered pollutants because they occur, in part, from natural processes regardless of man's activities. Setting of water quality

7. Maletic, *supra* note 3.

8. *Id.*

9. Pub. L. No. 89-753, 80 Stat. 1246 (1966), *amending* the Water Pollution Control Act, ch. 758, 62 Stat. 1155 (1948), *as amended* by the Water Pollution Control Act Amendments of 1956, ch. 518, 70 Stat. 498 (1956). [The Water Pollution Control Act with these amendments was formerly codified at 33 U.S.C. § § 466-466g (1958). It is now codified, with later amendments, at 33 U.S.C. § § 1251-1376 (Supp. III. 1973) (Ed.).]

10. Pub. L. No. 89-234, 79 Stat. 903 (1965), *amending* 33 U.S.C. § § 466-466g (1958).

11. Federal Water Pollution Control Act Amendments of 1972, Pub. L. No. 92-500, 86 Stat. 816 (1972), *amending* 33 U.S.C. § § 1151-1175 (1970) codified at 33 U.S.C. § § 1251-1376 (Supp. III, 1973).

12. 33 U.S.C. § 1251(a) (Supp. III, 1973).

13. 33 U.S.C. § 1311(b) (Supp. III, 1973).

14. *See* 33 U.S.C. § § 1341-45 (Supp. III, 1973).

15. 33 U.S.C. § 1318 (Supp. III, 1973).

standards for salts was opposed as being unenforceable. Now, however, there is a strong intent expressed by the Federal Environmental Protection Agency to apply such standards. In the meantime, consideration is being given to methods of controlling both the natural sources of salt and those resulting from irrigation of land. Demonstration and research projects are being initiated to determine if changes in irrigation water management practices can effect a reduction in the salt load of the river. Feasibility investigations are being made to evaluate alternative methods of controlling salt which enters the river from natural point sources such as mineral springs, geysers, and the like. So the issue of salt in the Colorado River water is not entirely an international one but is of great concern to the United States on account of its clean water policy.

Furthermore, users in Arizona and California who are suffering injuries, as mentioned earlier, are not going to be complacent about even a 1 ppm increase in salinity of the river. And, of course, Mexico has served notice that it will protect its interests in the river.

The international implications of both amount and quality of water reaching Mexico have not been fully realized by many water users in the United States. They have been aware, of course, of the treaty with Mexico which assures delivery of 1.5 maf annually from the Colorado River.[16] The problem of quality of that water has not been given much attention by the general public in spite of the fact that diplomatic exchanges have extended over many years and the International Boundary and Water Commission has been actively discussing the issues and, in fact, has taken action under Minute 218[17] to bring about some improvement.

The salinity problem in the Colorado River is aggravated by the fact that some water is diverted out of the basin by the Upper Basin States. Each 100,000 acre-feet taken out of the basin from the headwaters is estimated to cause an increase in salt concentration of 10 ppm in the lower river.[18] The diverted water would otherwise serve to dilute the concentration of salts in the river. Similarly, consumptive use or diversion from the river without return causes the same effect. For example, if oil shale is developed as an energy resource in the Upper Basin, it will require substantial amounts of water for shale processing, associated domestic use, and stabilization of spent shale residue by revegetation. It is estimated that the

16. Treaty with Mexico Respecting Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, February 3, 1944, art. 10(a), 59 Stat. 1219, 1237 (1945), T.S. No. 994.

17. 4 Int'l Legal Materials 545 (1965), 55 Dep't State Bull. 555 (1965).

18. U.S. Dep't of the Interior, *supra* note 6.

amount of water needed for production of one million barrels of oil per day would increase the salinity by about 4 ppm in the Lower Basin, assuming that all of the water is consumptively used.[19]

In connection with oil shale development, there is also the possibility that dewatering operations at mining sites will produce a highly saline water which will present a disposal problem. Obviously, water quality regulations will not permit its discharge into the Colorado River or tributaries.

New irrigation land development which is contemplated in the Upper Basin may be expected to have definite impact on the salt load. Its effect will be variable depending upon geological conditions at the irrigation project, efficiency of the irrigator, and the amount of salt placed into solution as water percolates through soil and substrata in return flow to the river. For example, the Florida Project and part of the Delores Project in Colorado contribute virtually no salt to the river, while the Grand Valley and Uncompahgre irrigated areas contribute from two to eight tons per acre annually.[20]

Relatively little salt is contributed to the river from municipal and industrial effluent. In general, these sources generate 200 or 300 ppm of salt above that which is in the supply water.[21]

Planning is in progress on methods of controlling the salt load in the Colorado River. Two general alternatives are being considered: (1) control of salt sources (point sources, diffuse sources, irrigation sources) and (2) alteration in river system management including utilization of return flow for other purposes.

Additional measures are being investigated which would contribute to the solution of the problem. They include cloud seeding to increase precipitation and add additional diluting water to the system, sea-water desalting to produce replacement water in the Lower Basin and the desalting of brines produced from deep geothermal wells.[22]

Several point sources of salt contribute substantially to the salt load. Their control would reduce substantially the salt load. Among them are LaVerkin Springs and Crystal Geyser in Utah, Blue Springs and Littlefield Springs in Arizona, and Dotsero Springs, Glenwood Springs, and Paradox Valley in Colorado.

LaVerkin Springs might be controlled by the construction of a diversion dam upstream from the spring to divert the normal river

19. U.S. Dep't of the Interior, Draft Environmental Statement for Proposed Prototype Oil Shale Leasing Program, vol. 1, Sept. 1972.

20. Maletic, *supra* note 3.

21. *Id.*

22. *Id.*

flow around the springs. Flow from the springs would be collected for desalting, returning the product water to the Virgin River through a 1,600 ft. pipeline. The brine from the plant would be conveyed 3.5 miles to an evaporation pond. This project will cost about $20 million.[23]

The Paradox Valley in Colorado contributes about 200,000 tons of salt per year to the Delores River, a tributary of the Colorado River. The salt originates in an unusual salt "dome" which was upthrust to a position near the surface. Underflow of the Delores River interfaces with the salt brine from the dome where it is mixed and brought into the surface stream. By pumping from the lower ground water, the brine-fresh water inferface can be lowered which will reduce the extent of mixing and eliminate about 180,000 tons of salt per year. Pump discharges of around five cubic feet per second would do the job, and the brine discharge would be evaporated for disposal. Control at this source will cost approximately $16 million.[24]

In the Glenwood-Dotsero section of the river in Colorado, eighteen springs discharge about 25,000 acre-feet of water containing 500,000 tons of salt into the river annually. Littlefield Springs on the Virgin River in Arizona discharges 10 cubic feet per second and produces 30,000 tons of salt annually. Blue Springs on the Little Colorado River about 13 miles from the main stem is the largest point source of salts in the entire system, producing 220 cubic feet per second and yielding 550,000 tons of salt per year.

Feasibility studies have not yet progressed for these last three sources such that cost estimates or control plans are yet available.

Diffuse loadings from irrigated areas are substantial from the Colorado Valley Basin in Colorado, the Colorado River Indian reservation in California and Arizona, the Lower Gunnison Basin in Colorado, the Uintah Basin in Utah, and the Palo Verde irrigation area in California.[25]

Salts which return to the river as a result of irrigation represent around 37 percent of the total annual load of 10 million tons.[26] Control measures for this source are not reliably established, but several good possibilities are being tested. The Grand Valley irrigated area in Colorado contributes 700,000 tons of salt annually from 76,000 irrigated acres. Improvements in the management of irrigation water and the prevention of seepage losses from canals are

23. U.S. Dep't of the Interior, *supra* note 6.
24. *Id.*
25. Maletic, *supra* note 3.
26. U.S. Dep't of the Interior, *supra* note 6.

being depended upon heavily to reduce some of the salt load. Improved scheduling of irrigation, improvements in the precision of water control and its application, new methods of precise water application (trickle irrigation), and similar measures are all being tested at field scale demonstration sites. It is estimated that these measures could reduce the salt load in the Colorado River by 200,000 tons annually, at an estimated cost of $59 million.

Diffuse sources are not well identified nor fully defined but the Price River, San Rafael River and Dirty Devil River in Utah, McElmo Creek in Colorado, and Big Sandy River in Wyoming are known for heavy salt contributions. The Big Sandy River produces 180,000 tons per year.[27] McElmo Creek in Colorado produces 115,000 tons per year.[28] The Price, San Rafael, and Dirty Devil Rivers in Utah produce 630,000 tons per year.[29] Being diffuse in nature, it is rather difficult to devise methods of selective withdrawal and desalting or other treatment. We simply do not know enough about the nature of these sources to devise remedial measures.

The program described above for improving the quality of Colorado River water will be implemented by the U.S. Bureau of Reclamation provided the Congress of the United States authorizes it.[30] About 2.5 million tons of salt would be removed from the river annually, reducing the concentration at Imperial Dam from its present level of 860 ppm to about 660 ppm by the year 2000.[31] The cost of the total program including control of point sources, diffuse sources, and irrigation sources would be extremely high according to present estimates which are undoubtedly optimistic. Other potential control measures which have yet to be investigated include alternative schemes of managing the river system, new and innovative methods of removing salt from the river (such as precipitation within reservoirs), reduction of evapotranspiration through vegetation on watersheds to increase runoff, cloud seeding to increase precipitation, sea water desalting, desalting of geothermal brines, and desalting at the points of diversion to meet the quality requirements of the intended users.

It goes without saying that whatever remedial measures are applied, the cost to the people of the United States will be great. Quite likely, costs will be reckoned in both monetary and water

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27. Maletic, *supra* note 3.
28. *Id.*
29. *Id.*
30. The Colorado River Basin Salinity Control Act was enacted on June 24, 1974, Pub. L. No. 93-320, 88 Stat. 266 (1974) [Ed.].
31. Maletic, *supra* note 3.

terms. Nevertheless, the people of the United States have determined that they wish to have and maintain a high level of water quality and have dedicated a very large amount of their fiscal resources toward that end. The problem of salinity in the Colorado River is only a part of the total problem, and up to now it is one which has been greatly overshadowed by industrial and municipal pollutants in other regions, particularly the heavily populated areas.