RU # 303

Environmental Impacts of Desalination in the United States 1/

Frank T. Carlson and Elizabeth G. Macalaster

Office of Water Research and Technology
United States Department of the Interior
Washington, D.C. 20240

1/ Presented at the International Congress on Desalination and Water Re-use, Nice, France, October 21-27, 1979

INTRODUCTION

Sales of desalting systems demonstrate the important contribution that this technology is making to augment existing water supplies. As with any technology, however, proponents have responsibility to assure that in its application, no significant environmental problems arise that would offset the benefits.

In the United States, Federal legislation in the past decade has emphasized protection of environmental quality. As a result, practically all desalination units require at least an assessment of their potential environmental impact. Regulations pursuant to provisions of The National Environmental Policy Act spell out conditiions and methods for these assessments and followup activities. In addition, the Water Research and Development Act of 1978 (P.L. 95-467), requires the Secretary of the Interior to carry out research, development and demonstration of desalination technology in a manner that is environmentally safe.

The purpose of this paper is to report on the environmental impacts encountered in desalination in the United States. The discussion covers only real or potential problems external to the facilities resulting from their location design and operation. This information results from review of the literature and contacts with over 100 individuals in government and industry.

FINDINGS AND DISCUSSION

The limited amount of information available indicates that the environmental impact of desalination activities in the United States to date has not constituted a significant problem. The scarcity of documentation is likely attributable to the small size of individual units and consequent limited effects.

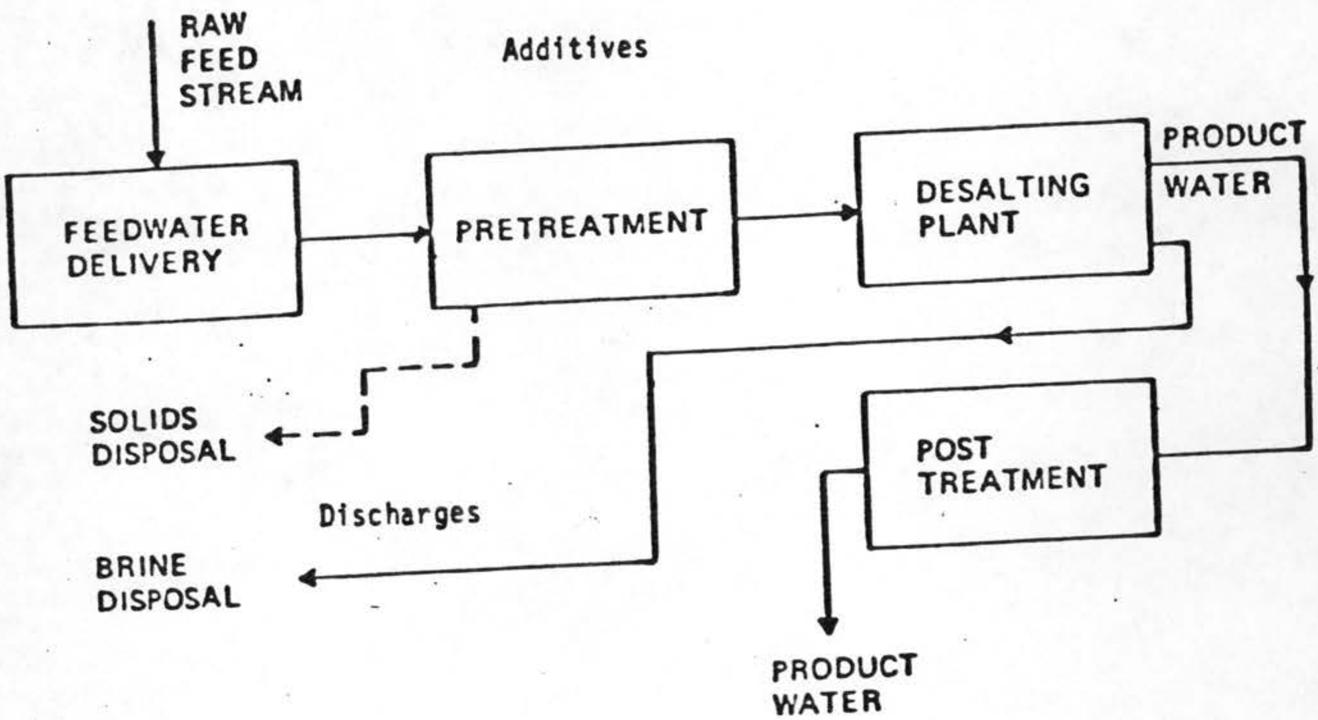
Of 500 units operated or under construction in 1977, only 24 had rated capacities over 1 MGD, with the largest rated at 5 MGD (OWRT, 1977). Where specific environmental effects have been documented, the information often has been used to forecast probable effects of operation of larger units (Legros, et al., 1968; Thomson, et al., 1969; Zeitoun, 1969; Chesher, 1971; Mandelli, et al., 1971; OSW and BuRec., 1972; VI HUD, 1972; OSW, 1973; and Peters, Bureau of Reclamation, communication, 1979). Ultimately, the significance of effects at any one site will be determined by characteristics of the site, design and operation of the units. The following discussion describes qualitatively the kinds of effects that may be encountered, especially with larger scale facilities, by interaction of these three determinants.

The site selected for a facility may be the most important determinant of environmental effects, their significance and costs of mitigation. Noise and vibrations have become a nuisance when a facility was located too close to residential areas (OWRT staff communication, 1979). Disturbance and displacement of wildlife at the proposed Yuma, Arizona 100 MGD facility will necessitate development of alternate habitats (Peters, Bureau of Reclamation, communication, 1979). Moreover, a site may be ruled out if determined to be in, or adjacent to the critical habitat of an endangered species of plant or animal. Where volume withdrawn exceeds that required instream to sustain populations of resident fish, mitigation measures likely will be required as at the Yuma site (Martin, 1979).

Velocity of surface water withdrawn can be a problem of intake structure design. Sustained intake velocities may be sufficiently great to trap excessive numbers of small-size fish on debris-removal screens or even entrain them.

Effects from desalting operations are largely related to disposal of waste. The brine stream's chemical characteristics and flow rate at the discharge point will influence the extent of its effects (Figure 1). Waste brine disposal in the marine environment may expose bottom dwelling biota to increases in water temperature, total dissolved solids (TDS), biocide residuals, descaling chemicals, and heavy metals, notably copper, to levels substantially above their tolerance limits. Temperature rises up to 10°C. are not uncommon at point of discharge from thermal process units and total dissolved solids may also increase by a factor of 1.3 to 2.0.

FIGURE I. GENERAL DESALINATION ADDITIVES AND DISCHARGES



Additives

- Descalers
- Biocides
- Coagulants

Discharges

- Corrosion products
- Increased:
  - additives
  - TDS
  - heat

For example, at Key West, Florida, Chesher (1971) found in a 15 month study that the interaction of elevated temperature and salinity controlled the depth and density of a brine stream with a copper content of 1,176 parts per billion (ppb), 10 times above ambient levels. The effluent, diluted about 20 times at point of discharge, sank to form a warm dense stratum. The stratum was about 3.5m thick and in contact with the bottom most of the time (Figure 2, Case I).

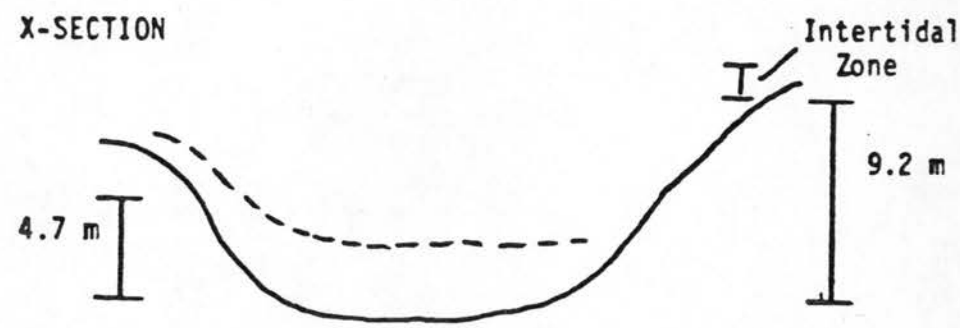
Sea squirts, sabellid worms, bryozoans and various species of algae and grasses disappeared in the areas exposed to the brine stream. Many of these biota are important items in the diets of bottom-feeding fish of the area.

Where copper (alone as cupric oxide) was discharged during flushing of the system after shutdown for plant maintenance, a density current did not form along the bottom. Instead the material dispersed in surface waters where it settled in intertidal areas (Figure 2, Case II).

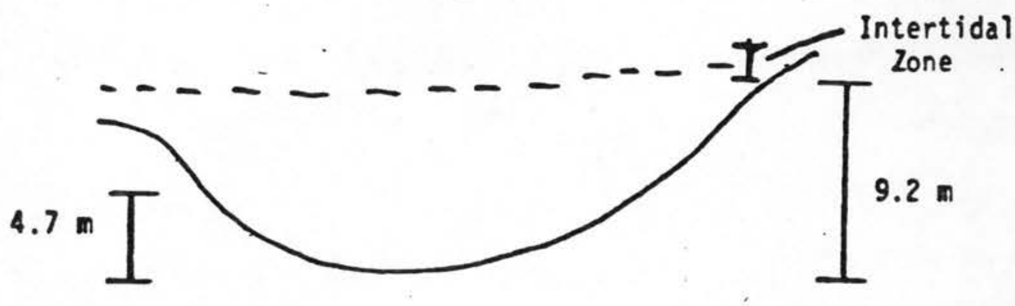
Ionic copper is well known for its toxicity to many biota. Oyster larvae (*Crassostrea virginica*) died following constant exposures of up to 96 hours at concentrations as low as .01 parts per million (ppm), while juvenile and adult oysters died over larger periods of exposure (Mandelli, et al., 1971).

FIGURE 2 TEMPERATURE/SALINITY/HEAVY METAL RELATIONSHIPS IN BRINE DISCHARGES TO MARINE WATERS

CASE I TEMPERATURE AND SALINITY > AMBIENT



CASE II TEMPERATURE AND SALINITY = AMBIENT



The accumulation of heavy metals, such as copper, several thousand times their concentration in water is a common attribute of food chains, beginning with plankton and ending with shellfish or carnivorous fish. For example, by ingesting copper-laden plankton, adult oysters have accumulated sufficient copper to become green, thereby making them unmarketable (Zeitoun, et al., 1969).

At Point Loma, California, Zeitoun, et al., (1969) attributed the decline in numbers and species of benthic biota to brine stream temperatures of 34° to 43°C. and salinities 1.5 to 2.0 times above ambient. In laboratory studies, he found that shrimp and oysters of the area became more susceptible to fungal infection when exposed to sublethal levels of temperature and salinity characteristic of the brine stream at point of discharge.

In a study of a theoretical release of brine stream from a proposed nuclear desalination and power plant to the Gulf of California, Thomson, et al., (1969) concluded that the TDS, heavy metal and biocide content could kill or injure shrimp and oysters. The proposed discharge site is the only important spawning and nursery areas for the commercial fish "Totoaba" (Hendrickson, 1979), an endangered species (Federal Register, 1979).

Sludge disposal from larger scale plants than now exist likely will require special controls to prevent deterioration of air and water quality. The greatest need will be at inland sites where lime will be used for pretreatment and slurry transported to evaporation ponds. At Yuma, Arizona, for example, ponds designed to receive up to 325 tons per day lime sludge will require lining with impervious materials to prevent percolation of leachates to aquifers, a source of irrigation water (Peters, Bureau of Reclamation, communication).

Although no significant air pollution has been observed at desalination plants, future regulations probably will necessitate covering of land disposal sites to prevent blowing of dried residues of potentailly hazardous content (Peters, Bureau of Reclamation, communication). Periodic emissions of hydrogen sulfide from future large scale plants may require monitoring and control to assure that their concentrations do no exceed limits for protection of terrestrial biota (OSW, 1972).

CONCLUSION

Regulations to protect the quality of the environment in the United States have and will continue to provide a procedural framework to safeguard against significant adverse environmental impacts of desalination. The nature and cost of safeguards will vary with the site, especially on systems larger than those in existence today. Project budgets must allow an appropriate percentage for the conduct of environmental assessments, impact studies and mitigation measures. The Office of Water

Research and Technology will support research and development which add new information on methods of avoiding or mitigating adverse environmental effects and on opportunities for beneficial uses of brines and sludges.

Literature Cited

Chesher, Richard H. 1971. Biological Impact of a Large-Scale Desalination Plant at Key West. Westinghouse Ocean Research Laboratory, Annapolis, Maryland, U.S. Environmental Protection Agency Project No. 18080 GBX. 150 p.

Federal Register. 1979. Office of the Federal Register, National Archives and Record Service. General Services Administration, Washington, D.C. 20408. Vol. 44, No. 89 (May 21, 1979), p. 29478 - 29480.

Hendrickson, J.R. 1979. Totoaba: Sacrifice in the Gulf of California Oceans 12(5): 14 Sept. - Oct. 1979

Legros, P.G., E.F. Mandelli. D.E. Winthrode, M.A. Zeitoun, Dow Chemical, 1968. Effect of Effluents from a Large Desalination Plant. Office of Saline Water. United States Department of the Interior, Washington, D.C. 20240. Research and Development Report #316. 274 p.

Mandelli, E.F. and W.F. McIlhenny. 1971. Study of Effect of Desalination Plants. United States Department of the Interior, Office of Saline Water, Washington, D.C. 20240. Research and Development Report #803. 152 p.

Martin, Guy. 1979. Statement of the Assistant Secretary-Land and Water Resources, United States Department of the Interior. Before the United States House of Representatives Subcommittee on Water and Power Resources on H.R. 2609 (A bill to Amend Title I of the Colorado River Basin Salinity Control Act.)

Office of Saline Water. 1973. Final Environmental Impact Statement. Five-Year Extension for Research and Development (Public Law 92-60) at six sites in the United States. United States Department of the Interior, Washington, D.C. 20240. 21 p.

Office of Saline Water and Bureau of Reclamation. 1972. Proposed Installation and Operation of a Skid-Mounted Desalting Unit and Injection Well in Imperial Valley, California. United States Department of the Interior, Washington, D.C. 20240. 22 p.

Thomson, Donald A., A.R. Mead, J.R. Schreiber. 1969. Environmental Impact of Brine Effluents in the Gulf of California. Office of Saline Water, United States Department of the Interior, Washington, D.C. 10140. Research and Development Report #387. 196 p.

United States Department of Housing and Urban Development. 1972. Virgin Islands Final Environmental Impact Statement of Desalination Plants. St. Thomas and St. Croix, United States Virgin Islands. 69 p.

Zeitoun, M.A., E.F. Mandelli, W.F. McIlhenny, Dow Chemical. 1969. Disposal of Effluents from Desalination Plants. Office of Saline Water, United States Department of the Interior, Washington, D.C. 20240. Research and Development Report #415. 123 p.