Chapter 8

International Involvement With Desalination

INTERNATIONAL APPLICATIONS

Most freshwater supplies throughout the world have been developed using conventional means, such as direct diversions, dams, or reservoirs for surface water, and wells for groundwater. Treatment of this water varies from none at all to the removal of suspended material and/or dissolved minerals causing hardness, and disinfection. Overall costs for water are generally less than $0.95 per 1,000 gallons. In the vast majority of cases, water from conventional sources, if it is available, will cost less than water produced by desalination (77).[1]

The development of distillation, reverse osmosis (RO), and electrodialysis (ED) over the last 30 years have made desalination a reliable and widely accepted technology throughout the world where conventional sources of water are limited. There are now about 3,500 plants in 165 countries worldwide with a total capacity of about 3 billion gallons per day (gpd) (33). This capacity could increase in the future with the development of extensive reserves of brackish groundwater found in northern and western Africa, Australia, Canada, southern and western Europe, Mexico, the Middle East, and South America (1 1,36).

Unfortunately, neither desalination nor any other non-conventional technology will provide inexhaustible and inexpensive supplies of freshwater. They all require sizable capital investments, trained support staff, continued long-term maintenance, and low-cost energy. For these reasons desalination is most viable in middle- to high-income countries. Costs of desalinated water are still beyond the reach of most rural communities in poorer countries. Even with projected decreases in the cost of reverse osmosis, this situation will probably not change substantially in the foreseeable future (77).

Additional technical information and a process for selecting desalination plants, especially for overseas locations, can be found in the Desalting ***Handbook for Planners*** (1 1), and the ***USAID Desalination Manual (8).***

Middle East

Because of limited freshwater supplies and the availability of oil revenues, the Middle Eastern countries of Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, and Bahrain have the world's greatest collective experience with desalination. For example, Saudi Arabia has a desalination capacity of about 900 million gallons pm day (mgd) (86); its capital of Riyadh alone uses about 270 mgd, or about 10 percent of the world's desalinated water (20).[2] Seawater distillation has been used to meet most drinking water requirements ever since the 1950s; however, over the last decade RO has been used increasingly for treating water from brackish aquifers and seawater wells.

In Middle Eastern countries desalinated water is used primarily for domestic, and industrial purposes. In a few countries (e. g., Saudi Arabia, Israel) it may be used for agricultural purposes. Although it may be more economical to import the crops that are irrigated with desalinated water, such operations are often undertaken for reasons of self-sufficiency and national security. In most cases desalination is heavily or entirely supported by the central governments. The market for desalination in the Middle East is now relatively ' 'soft' due to falling oil prices and currently stable water demand,

[1]Transporting freshwater in tankers from water-rich to water-poor regions of the world may also have some potential, especially during emergencies caused by unexpected droughts. For example, drinking water has been barged 60 miles from Puerto Rico to St. Thomas in the Virgin Islands for about $15 to $20 per 1,000 gal. At present, several water shipping schemes are operating and more are envisioned. In most of these cases, water from Europe is shipped to arid areas around the Mediterranean Sea or Persian Gulf (77). However, national strategies for self-sufficiency weigh heavily against reliance on long-distance transport of permanent water supplies.

[2]In Saudi Arabia about 73 percent of its 915 mgd capacity is provided by MSF distillation; RO accounts for 23 percent; and others, 4 percent (77). The Saudis have a unique network of water distribution pipes that extend from the Red Sea about 500 miles inland. Unlike the other Middle Eastern countries, the Saudis have in the past contracted for more MSF than RO units because of the experienced MSF work-force available within the country.

Arid Islands

There are many islands throughout the world that have limited freshwater supplies, but because of their natural beauty, mild climate, and strategic location have been developed for tourists and/or military bases. Over time these islands have become more and more dependent on desalination of seawater and brackish groundwater, if it is available. For example, the Virgin Islands, Bahamas, Marshalls, Netherlands Antilles, Antiqua, Ascension, Bermuda, Cayman, Canary Islands, Malta, and Cebu (in the Philippines) depend on desalination to produce some or all of their municipal water supplies. Curacao (Netherland Antilles) has been using desalination since 1928. Both the Netherlands Antilles and the Virgin Islands produce more desalinated water than such countries as Great Britain, Mexico, Australia, Israel, and Germany.

The water produced on these islands is usually used within city limits where there are adequate supplies of fuel or electricity and a water distribution system. In many urban and rural areas on islands throughout the world (e.g., Marshall Islands, Bermuda) roof catchment systems are still used to collect and store freshwater.

Other Arid Countries

In countries where desalination is affordable, but not yet in widespread use, it is usually more practical, from an economic and security standpoint, to build and maintain small decentralized RO or ED plants supplied by brackish groundwater, than to distill the water at a large centralized facility and pipe it to outlying areas. For example, resorts along the Mediterranean and the Caribbean Seas typically use small seawater RO plants. A number of small rural communities in Mexico also use brackish water RO to satisfy most of their drinking water needs. The modular construction of RO and ED plants also allows for incremental expansion of capacity as the demand increases. Vapor compression (VC) distillation plants can also be cost-effective.

In some arid countries desalination capacity has expanded considerably over the last decade. For example, between 1957 and 1979 Mexico built 35 plants with a combined capacity of 1.1 mgd. Through the combined efforts of the government, industry, and tourist resorts, Mexico now has 79 operating desalination plants. Since 1980, industry has built most of the plants and is presently the largest producer of desalted water in Mexico.

In very remote areas small solar stills (described in app. A) may be an appropriate alternative (77).[3] For example, solar stills had been used for short periods of time in Australia, Greece, and Mexico up until 1980, but were phased out of use when other sources of freshwater were developed.

Industrialized Countries

Other than the United States which has almost 10 percent of the world's desalination capacity, there are very few industrialized countries using desalination to any large degree. This is probably because the majority of the industrialized countries are located in temperate zones where there are adequate supplies of freshwater. As in the United States, desalination technologies are used in most industrialized countries primarily for industrial purposes, and secondarily for drinking water.

Since drinking water and wastewater discharge standards are often changed overseas as laws in the United States are amended and/or standards developed, the use of desalination technologies may increase in many industrialized countries.

Lower Tier Developing Countries

In most developing countries water for domestic, industrial, and agricultural uses comes from surface and groundwater supplies. Water treatment, if there is any, generally involves conventional treatment (e. g., sedimentation, fdtration, and disinfection) of surface water supplies. The level of water treatment is typically much lower than it is in industrialized countries. Drinking water is often delivered through leaky pipelines to standpipes that serve several hundred people in a neighborhood. In many developing countries the demands for drinking water exceed existing supplies, especially in cities with rapidly growing popula-

[3] **More information on solar stills can be found in the** *Manual on Solar Distillation of Saline Water (83)* **and U.S. Agency for International Development's** *Fresh Water from the* **Sun (18).**

tions. As of 1983, 52 percent of the population in developing countries had water supplies that were considered adequate in terms of quantity and quality (i. e., disinfection); 29 percent had adequate sanitation facilities. As expected, water supply improvements generally occur first in urban areas (78).

Unfortunately, the technology of industrialized nations can not be easily transferred to many developing countries. Necessary construction materials are often lacking; the electricity required to operate water treatment facilities may be in short supply; and the infrastructure required for municipal water treatment (e. g., knowledgeable administrators, trained workers, ready availability of supplies and equipment, etc.) often does not exist. These inadequacies are compounded by the fact that once the water is used there is often no systematic and sanitary method for collecting and/or disposing of waste water. In fact, indoor plumbing is more often the exception rather than the rule; the nearest field, gutter, or water body may be the only available disposal option.

Small scale, portable RO units are routinely used by the military in remote areas of the world to provide potable water. These same units could be used in urban and peri-urban areas of developing countries to supplement existing supplies of potable water by desalinating and treating seawater, polluted surface water, or brackish groundwater. However, to do this would require dependable energy supplies, trained personnel to operate the units, and a logistical system to supply spare parts for the life of the project. Also, the water from these units costs in excess of $10 per 1,000 gallons.

For these reasons, desalination is usually either too expensive or too impractical for general use in most developing countries. In fact, desalination costs in developing countries will generally be at least twice as much as they are in the United States. In addition to technical and economic constraints associated with desalination, there can be sociological problems when relatively sophisticated technologies are introduced into villages where age-old traditions have prevailed (77).

U.S. GOVERNMENT INVOLVEMENT IN INTERNATIONAL ACTIVITIES

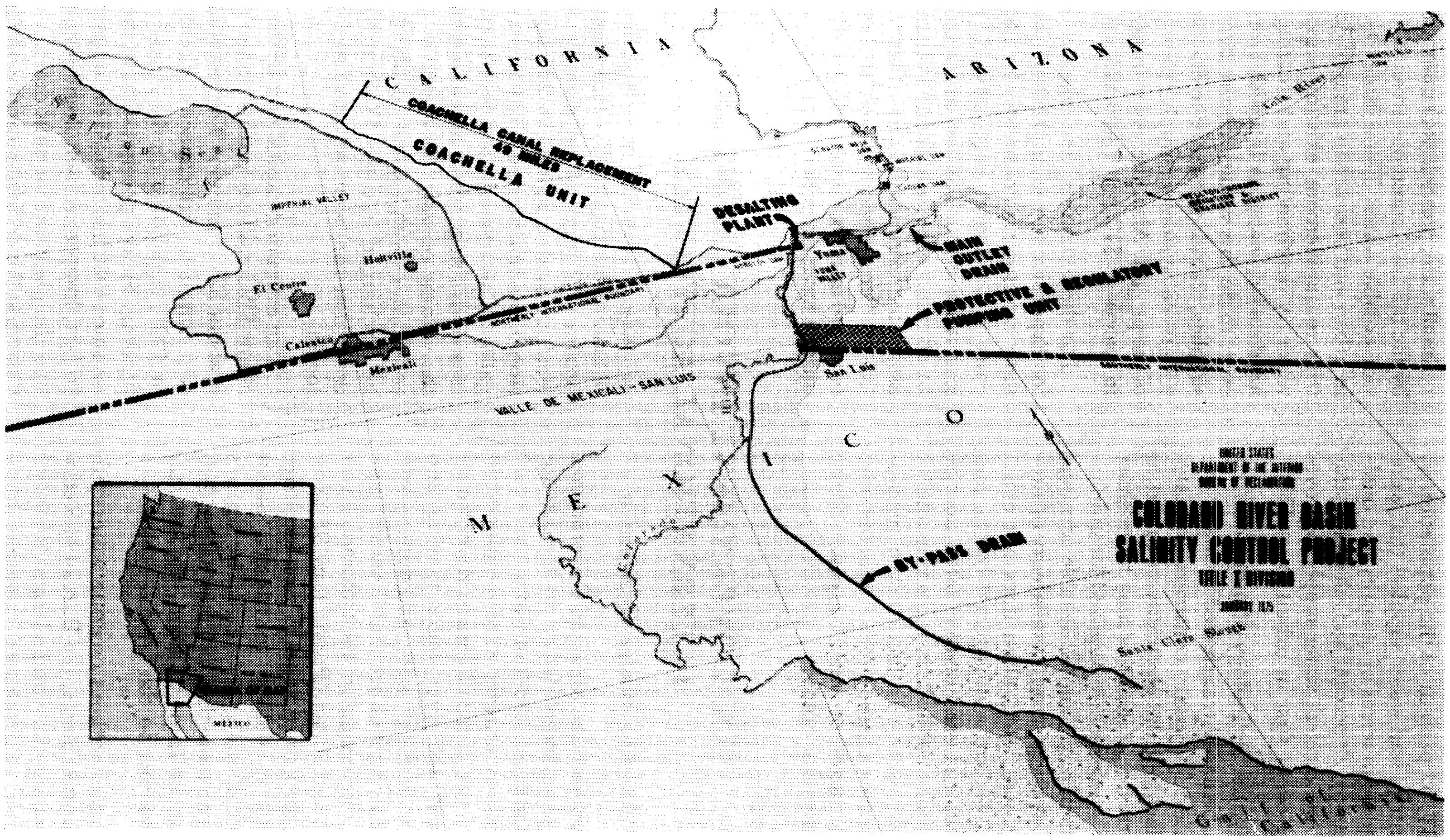
Supplying Fresher Water to Mexico

In a 1944 treaty with the Mexican Government, the United States agreed to deliver to Mexico approximately 1.5 million acre-ft of water each year. However, no salinity criteria were mentioned in the treaty. As the use of the Colorado River for irrigation increased, the river water flowing into Mexico became increasingly salty, and decreasingly useful for Mexican agriculture and domestic purposes. In 1974 Congress passed the Colorado River Basin Salinity Control Act (Public Law 93-320). This act allowed the United States to meet its pledge (in Minute 242) to deliver to Mexico about 1,360,000 acre-ft of water per year. The water's salinity would be no more than 115 ppm saltier than water arriving at the Imperial Dam, the last major diversion structure in the United States.

To meet this goal without creating water deficiencies in the United States, the Bureau of Reclamation is constructing the world's largest RO plant at Yuma, Arizona, to desalinate irrigation drainage water that would otherwise flow into the Gulf of California (figure 12). This plant is designed to produce 72 mgd, or an average of 67,000 acre-feet/year with a salinity of 295 ppm at an operational and maintenance cost of about $1 per 1,000 gallon. This treated water will be blended with untreated drainage water and as a result will increase the volume of water by about 10 percent. Waste concentrates with a salinity of about 9,800 ppm will be discharged into the Wellton-Mohawk bypass drain that has been extended to the Gulf of California.

The estimated capital cost of the Yuma plant is about $215 million and its annual operating cost is about $27.5 million. The plant is about 80 percent complete; full capacity is scheduled for 1992 or 1993, depending on the availability of Federal funding. Heavy precipitation in the Colorado Basin since 1980 has reduced the urgency for the plant. In fact, long-term hydrologic predictions indicate that the plant will be shut down 1 year in 4 when Colorado River flow naturally provides ample sup-

Figure 12.—Colorado River Basin Salinity Control Project



SOURCE: U.S. Department of the Interior.

plies of freshwater to Mexico after United States water uses are met. However, a 1 -mgd test facility at the plant will be operated on a full-time basis to evaluate the performance of new membranes and pretreatment techniques (75,76).

Other measures are also being undertaken to meet water quality standards established for diversions in the United States, to reduce the salinity of Colorado River water entering Mexico, and to improve irrigation efficiency. First, 49 miles of the Coachella (drainage) Canal in the Imperial Valley of California has been lined to reduce the seepage and loss of water. Second, the Wellton-Mohawk bypass that formerly carried irrigation drainage water into the lower Colorado upstream of the Morelos Dam has been extended through Mexico almost to the Gulf of California. Third, 21 wells were developed in southern Arizona to supply an additional 160,000 acre-feet of water per year to meet our obligation to Mexico. Another 10 wells may be added in the future. Finally, the Soil Conservation Service, with Bureau of Reclamation funding and oversight, implemented a program to reduce the generation of drainage water by increasing the efficiency of on-farm irrigation.

There are other rivers in the world's arid zones that present problems in international relations similar to those created by the development of the Colorado River. Eventually, desalination may play a greater role in resolving similar issues of water use elsewhere in the world.

Cooperative Technical Programs

In 1965 the United States and Israel jointly initiated a feasibility study for a dual-purpose nuclear plant located on the Mediterranean Sea, including the construction of a prototype desalination plant. In 1975 the United States and Israel began jointly constructing a 5-mgd distillation plant near the city of Ashdod, south of Tel Aviv. The plant was to test the practicality of coupling desalination to power generation, either from conventional, nuclear, or geothermal sources. Experts from the Office of Water Research and Technology worked with the Israelis and represented U.S. interests through an agreement with the U.S. Agency for International Development (9). This U.S.-supported work has helped to position Israel in direct competition with U.S. desalination firms.

During the early- 1960s the United States was also involved in the development of desalination in Saudi Arabia. At the request of the Saudis, the Department of the Interior (DOI) evaluated the feasibility of constructing a 5-mgd dual-purpose desalting plant at Jeddah. Burns & Roe, Inc., began designing a 2.5-mgd plant in 1966; actual construction began in 1968. Although funding for plant construction was provided by Saudi Arabia, the United States was allowed to use data developed from plant operations to further the development of desalination technology (9).

During the mid- 1970s the United States was involved in several other activities with the Saudis. First, DOI provided technical expertise to the U.S. Army Corps of Engineers on the design of a distillation plant at the Saudi Naval Base near Jeddah. This plant was completed in 1976. **Second,** DOI also agreed to help the Saline Water Conversion Corp., Saudi Arabia, establish a Research, Development, and Training Institute capable of handling 750 students to be trained in desalination plant operation at the Al Jubail desalination complex. Construction of the Institute, which began in 1982, was completed in 1987. The Institute has laboratory facilities, a power plant, and desalting equipment. **Third,** projects were also initiated to develop the technology for building and operating single unit, multi-stage flash (MSF) distillation plants with capacities of up to 66 mgd. Presently there are three to four Bureau of Reclamation personnel working cooperatively in Saudi Arabia. Funding for all these projects has been provided by the Saudis (9).

From the mid-1950s through the early 1980s technical information from the federally supported desalination research and development program was freely transferred to other countries of the world through published technical papers and international conferences. Production licenses on patented desalination technologies were also given to other countries by the United States. Special programs for exchanging information on desalination and other water resource issues were established with several countries, including Mexico and Japan.