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Saving Water in Texas Industries

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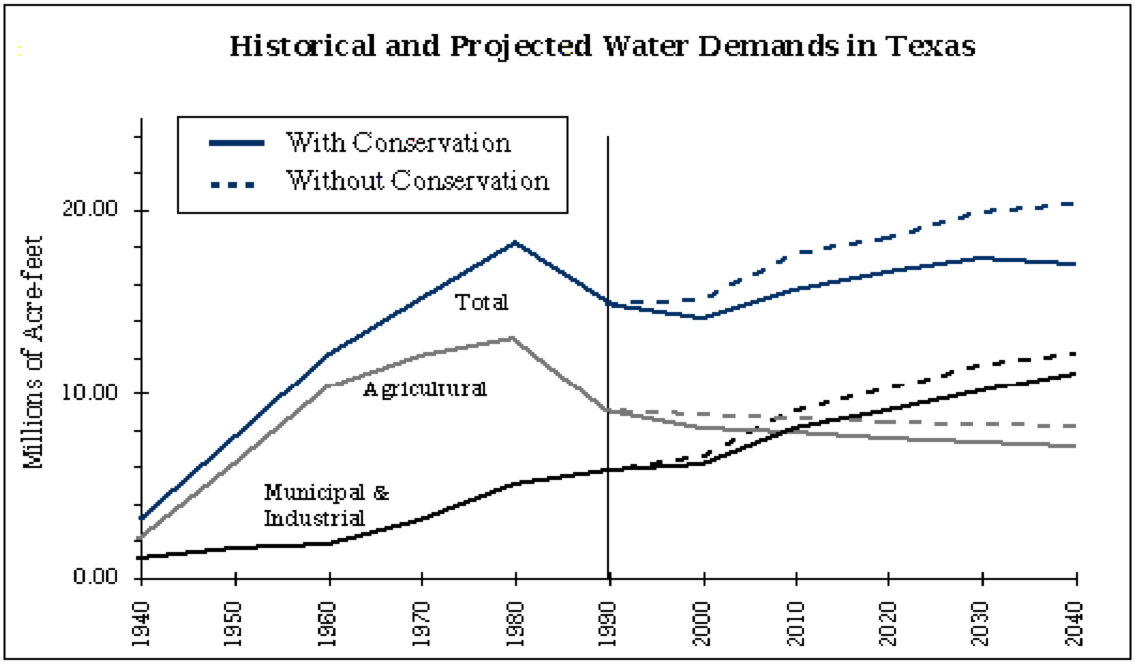
Throughout Texas, economic development and demand for water have been marching forward hand in hand, gradually surpassing the ability of regional water supplies to meet growing water demands in some parts of the State. Ensuring adequate, high quality water for human needs is among the most critical issues now facing Texas. Ensuring that water is available for Texas' industrial water users is vital to the State's economic future. In light of the prevailing scarcity of water, a climate of water conservation is evolving in Texas and will likely continue in the future. More emphasis than ever before is being placed on water conservation by homeowners, municipalities, and industries. This issue of *Texas Water Resources* focuses on industrial water conservation in Texas, and points out problems and success stories.

Historical Trends in Industrial Water Use

Industrial use of fresh (non-saline) water currently accounts for more than 40% of non-agricultural water use in Texas, and is expected to continue to increase (*Hoffman*, 1993). The Texas Water Development Board (TWDB) has kept records of water use in Texas, and it is clear that water use has changed significantly since World War II. This period has seen the rise, and now decline, of agricultural water use for irrigation. During this time, industrial and municipal water use rose rapidly as Texas grew to become the second most populous state and home to many major industrial centers. During the 1980s, Texans used 14 to 18 million acre-feet (AF) of water a year, or about 12 to 16 billion gallons per day. Roughly 67% of this amount went for crop irrigation and the remaining 33% was for municipal and industrial uses. Municipal and industrial water use has continued to grow, while agricultural water use has declined as shown above in Figure 1 (*Hoffman*, 1993). Table 1 shows manufacturing water use in water from 1960 to 1990.

By 1990, municipal and industrial water rose to 5.3 million AF per year. Water for residential purposes, including apartments, accounted for 48% of this use; commercial, institutional, and governmental uses totaled 11%, and industrial uses (power generation, mining, and manufacturing) accounted for 41%. This amounts to 1.56 million AF per year for manufacturing: 180,000 AF per year for mining (including oil and gas production), and 440,000 AF per year to generate steam electric power (Figure 2). An additional 7 million AF of saline water is used annually by industry mainly for once-through cooling at power plants on the Texas Gulf Coast (*Hoffman*, 1993).



Today, five industrial sectors (chemicals, steam electric power, petroleum refining, pulp and paper, and primary metals) account for 81% of the 2.2 million AF of industrial fresh water used in Texas (see Figure 3). The way water is used in these industries is also important. In 1990, steam electric power plants, used roughly 95% of their total water used was for cooling. In the manufacturing sector, cooling water accounted for 52% while process water accounted for 28%, and boiler feed represented 16%.

Specific manufacturing processes often determine water use. For example, 55% of the water used by the petroleum refining industry was for cooling processes. By contrast, 85% of the pulp and paper industry water use and 65% of the electronics industry water use was for processing (figures 4 and 5) (*Hoffman*, 1993).

Table 1. Freshwater Use for Manufacturing in Texas (1960-90)

Year	Water Use (1000s of acre-feet)
1960	775
1965	981
1970	1,169
1974	1,599
1980	1,520
1985	1,428
1990	1,556

Conservation Trends

Clearly, many factors including rising water costs, limited water supplies, and issues such as waste minimization, pre-treatment, and pollution control are making industries and the utilities that serve them take a new look at the role for increased water-use efficiency, water reuse, and other technologies (*Hoffman*, 1993). Industrial water conservation (used here as a broad term to include the array of reuse, reclamation, improved efficiency, and similar processes) has been motivated by economic and regulatory incentives.

Since industries have to pay for wastewater treatment and discharge by volume, saving water is nearly always economical because it reduces overall wastewater treatment costs. In most industries, treatment costs far outweigh the actual cost of raw water. Increasingly stringent laws regulating environmental impacts of industrial discharge have motivated industries to minimize the amount of effluent that actually leaves the plant. In many cases, some type of effluent reuse or recycling is introduced as industries strive to achieve minimal (and even zero) discharge. Zero discharge means that discharge to the wastewater treatment stream is eliminated. All wastewater, after treatment, is converted to a solid waste by concentration and evaporation, or is reused onsite. As new plants are built, they are more likely than ever before to incorporate internal recycling technology as a means of avoiding the high cost of environmental compliance and retrofitting later on.

Regulatory incentives can be a two-sided coin. Although minimizing effluent discharge is often an advantage, reducing the volume of wastewater that is discharged will concentrate the levels of contaminants in the effluent. Since both the quantity and the quality of effluent discharged by industries is subject to governmental regulation, *any* changes in the nature of the effluent can require re-permitting for the industry -- a process that industries work very hard to avoid. This article discusses how industries in Texas are meeting these challenges, and how government and industry are working together to solve regulatory impediments that limit industrial water conservation in Texas.

Case Studies

Examples of industrial water conservation exist in Texas for almost every industrial sector. In an effort to learn more about statewide progress in industrial water conservation, the TWDB recently commissioned a survey that was performed by a company specializing in industrial water use efficiency (Pequod Associates, Inc.). More than 350 industries throughout Texas were surveyed, and provided the TWDB with valuable information on industrial water use and conservation in this State.

Consultants hired by Motorola collect water samples from one of the rainfall retention ponds at the Oak Hill facility in Austin. Water from the pond is used for landscape irrigation at the Austin site.

The survey results indicate that many Texas industries have already achieved significant water savings. Reported water savings ranged from little or no savings in the organic chemicals industry to a 19% savings in food processing and 33% savings in the semiconductor industry. The most common conservation practices reported were: 1) recycling of cooling and process water; 2) sequential reuse; 3) improved control systems; and 4) process modifications. Other savings included retrofit of plumbing fixtures, improved landscape irrigation, and use of automatic shutoffs (*Hoffman*, 1993). While many facilities reported they can still improve water use efficiency, some industries are already known for their ardent water reuse. In the petroleum and refining industry, it is not uncommon for plants to reuse water up to 50 times before discharging it (*Shifly*, *Betz Industrial*, personal communication, 1994). Overall, manufacturing water use has been steady for the last 20 years, which is largely due to water scarcity and high water and wastewater treatments costs (*Hoffman*, 1993).

The practice of recycling cooling tower water was the most widely reported water conservation practice by all industry groups, with huge variations in water savings, investment, and payback time. There were 16 reports of recycling cooling or process water in the TWDB survey, with actual water conservation ranging from 7 million to 3.3 billion gallons per year from an average investment of about $50,000 (*Pequod*, 1993). Other water conservation practices such as sequential reuse, leak repair, dry cooling, also showed significant variation in water savings per dollar invested. Payback on water conservation investments seems to be highly plant specific.

Specific industries perform differently with respect to water use efficiency and the relative economic importance of water conservation measures. There are geographic variations in water use. The amount of water used to refine a barrel of oil in Texas varies significantly (*Hoffman*, 1993). Refineries in the Corpus Christi area and West Texas (El Paso, Odessa, Big Spring) use only half as much water per barrel of refined oil as do the refineries along the upper Gulf Coast from Houston to Beaumont. Some of this variation can be explained by different refinery operations and final product grade. The underlying reason is that water scarcity (which translates into higher water costs) in the Corpus Christi region has motivated refineries there to use water more efficiently (*Hoffman*, 1993).

Some water use variation stems from different industrial processes. In some sections of the chemical industry, water and water treatment costs are a major component of the overall production costs, so industries have an incentive to emphasize conservation measures, even though a large capital outlay may be required. Even though the motivations for water use efficiency appear to be different, the underlying reason is economics. If it pays to save, reuse, recycle, or reclaim water, then industries will probably find a way to do so. This also suggests that price can have an impact on how industrial water is used.

The TWDB records show the chemical industry is the largest water-using industrial sector in Texas, so attitudes about water use efficiency and conservation in this industry are clearly important. The chemical industry is so large and diverse that generalizations about water use efficiency cannot be easily made. Water use varies with production level, process, and geographic location. Even so, the TWDB's survey indicated that chemical firms in Texas generally consider water conservation to be a relatively high priority.

By contrast, there are industries which consider water use efficiency to be a relatively low priority, but still believe they are adhering to state-of-the-art conservation technologies. In fact, some of these industries are not efficient when compared to national standards. For example, much of the effort to conserve water in the pulp and paper industry has been motivated by changes in effluent discharge regulations. The idea is to strike an balance between maximizing water reuse and conservation and minimizing the form and concentration of pollutants in the waste stream. In general, less water used for processing means that less effluent is discharged. Nationally, water use in the industry has declined by about 35%. The trend in Texas mills ranges from water savings of 0 to 10%, although some mills have reduced water use by 25% to 45%.

Many paper mills in Texas are using conventional water conservation measures, such as counter current washing in the pulping and bleaching process, stream stripping, reuse of cooling water, and closed screen rooms. Conventional measures can cost on the order of $4 to $5 million to implement and generally take 2 to 3 years to pay back (Brown and Root Engineering, personal communication).

The newer "vapor compression evaporation" technology for water conservation is used less widely nationally, and is not believed to be in use in any Texas paper mills. The technology is expensive (roughly three times the cost of traditional technologies), but can recycle between 30% and 100% of a mill's water. Attaining zero discharge in any industry is rare.

Many computer-related industries (specifically semiconductor and printed circuit board manufacturing) are investing in water reuse, efficiency, and conservation. Throughout Texas, cities are competing for the high-tech industry because of its potential for providing "clean" jobs and economic gain. Ironically, high-tech industries are also high-water use industries. In 1992 in the City of Austin, six of the top nine water users were high-tech industries (see Table 2).

Large amounts of water are used in the semiconductor industry for rinsing and cleaning etched wafers. A typical semiconductor manufacturing plant produces ultra-pure water at great expense. Plant managers consider the cost of raw water and effluent treatment to be important (*Pequod*, 1993). Although many of the larger semiconductor plants believe their existing technology is state-of-the-art, some of the smaller plants feel there is room to improve water use efficiency. In Austin, monthly water consumption by the semiconductor and printed circuit board industries is roughly 155 million gallons, or 4.5% of the total water produced (*Camacho*, 1993).

A variety of water-saving technologies are now used by high-tech industries in Texas. The Austin IBM plant has implemented many water conservation projects over the last several years. One project was the elimination of a water-based cleaning process to a "No-Clean" solder paste manufacturing process, which reduced water-use by 50,000 gallons per day. Automatic process sensors have been added to equipment to ensure that rinse water is shut off when parts are not being processed. The plant recycles 64,000 gallons of process water and 15,000 gallons of effluent per day. These projects reduced water use at the plant by 64 million gallons (14%) between 1992 and 1993 (*Gayle Woodside, IBM,* personal communication, 1994).

Austin's two Motorola facilities together use almost 100 million gallons of water per month, and both employ simple and advanced water reuse and efficiency technologies to increase conservation. An estimated 21.5 million gallons of water per month are saved in the two plants through a combination of reusing effluent in cooling towers, reusing reverse osmosis (RO) reject water in scrubbing operations, and reclaiming scrubber, boiler, and cooling waters (*Anderson*, 1993).

The Motorola Oak Hill facility utilizes a double-pass RO membrane separation method to treat a portion of its incoming city water for use in the plant's cooling system. In the RO process, dissolved ions are removed from water by forcing pressurized water through a semipermeable membrane that restricts the passage of most dissolved materials. This results in a relatively ion free treated product water stream and wastewater (reject) stream with a relatively high total dissolved solids content. The RO reject water is reused in the cooling towers, the pollution abatement scrubbers, and, potentially, for landscape irrigation (*Weerakoon*, 1993). The Oak Hill facility conserves an estimated 21 million gallons of water per year by capturing rainwater and using it for turf and landscape irrigation on its 150-acre site. Average annual irrigation demand is estimated at 25 million gallons, and approximately 21 million gallons are collected through the capture and retention network (*Weerakoon*, 1993).

The Texas Instruments (TI) facility in Austin captures roughly 35 million gallons of water per year through conservation (a 25% overall reduction in water use). This results in a savings of $175,000 per year. When TI established its recycling program, it was buying city water at the rate of $2.26 per 1000 gallons, and paying the city $3.58 per 1000 gallons for wastewater treatment; clearly, it was economically sound to begin recycling water at the facility. The plant established the water recycling project in 1988. Previous conservation efforts included an employee awareness program, cascade-flow rinse, auto stops, recycled scrubber water, reuse of RO reject water, and better maintenance of cooling towers (*Mike Daniels, TI*, personal communication, 1994).

The TI employee awareness program educated employees on water conservation; the contra or cascade flow rinsing that conserved water by bathing products in tanks with progressively cleaner water; equipment that automatically stopped machines when products were not present, and air scrubbers that use treated wastewater. From 1988 to 1990, TI used RO reject water to mix chemicals and total water use decreased from 127 million gallons to 86 million gallons (*Anderson*, 1993).

The Pequod study projected many industries are likely to reduce their water use over the next 15 years. For example, they estimate that the semiconductor industry in Texas may reduce its water use by 40% over the next 15 years, based on anticipated technological changes and projected higher charges for water and wastewater treatment. Pequod also projected that the food processing, petroleum refining, and chemicals industries could cut water use by 15%, and that the pulp and paper industry could reduce water use by 25% because of anticipated technological changes (*Hoffman*, 1993; *Pequod*, 1993). Even if these projected reductions are accurate, municipal and industrial demands for water are still expected to surpass irrigation demand. This could lead to escalating costs for municipal and industrial water (*Hoffman*, 1993).

Table 2. Top Water Consumers in Austin (1992)

Customer	Volume
*Motorola	62.21
AMD	49,94
University of Texas (all sites)	41.71
*IBM	35.96
*Motorola	30.44
*Abbot Labs	18.99
Bergstrom Air Force Base	15.15
*Sematech	13.26
*Texas Instruments	9.02

**Sites with asterisks are "high tech" water users.*
Flows are in millions of gallons per month.

Industries and Utilities Team Up

With greater demand for water resources, more emphasis on industrial water conservation, and new rules on the quantity and quality of industrial effluent discharge, industries and water utilities are foregoing their historically adversarial relationships in favor of partnerships forged in common goals. One of the "buzz" phrases in today's climate is "pre-treatment." Across the country, cities (through their municipal utilities) entice industries to locate in their area and "pre-treat" the effluent stream prior to discharging it to the city's wastewater system. Typically, discharge permits for industries require them to treat effluent to a certain degree before discharge to the municipal wastewater system. Historically, the understanding has been that the water utility would then treat the effluent again in its own treatment system. With pre-treatment, more industries are taking responsibility for thorough (secondary and sometimes tertiary) treatment prior to discharge. In exchange, they may get a discount on water charges, tax rates, or other financial incentives.

One example of an innovative partnership between industry and municipality exists in the City of Harlingen with its new Fruit-of-the-Loom t-shirt plant. The City, located in the Lower Rio Grande Valley region where water is in short supply, badly wanted to attract a larger industrial base. However, in addition to the insufficient supply of water, the quality of the potable water has often been too "hard" for many types of industries to use without additional treatment. These factors combined to keep many industries away. In the end, the City of Harlingen, and Fruit-of-the-Loom joined forces. The City takes 2 million gallons per day (mgd) of its treated wastewater (which would normally just be discharged) and further treats it using RO processing. The RO process lowers the salt content and this water is provided to the Fruit-of-the-Loom plant for reuse as process water. The plant then pre-treats the water and sends it back to the city for full, final treatment at Fruit-of-the-Loom's expense. By the time the water is finally discharged, it has been treated, used by the City of Harlingen, treated twice more (once with an RO process), used by the Fruit-of-the-Loom plant, pre-treated, fully treated once again, and finally discharged. The City of Harlingen gets the industry without putting a drain on its potable water supplies, and the industry gets a steady supply of high-quality water for reuse. Everyone wins. While the partnership currently involves 2 mgd, plans are underway to expand it to 3 mgd.

This pressurized flow-through filter system is part of the Reverse Osmosis treatment facility at the City of Harlingen Water Works. RO-treated water is reused by Harlingen¹s Fruit-of-the-Loom plant in its partnership with the City of Harlingen.

While this type of partnership may not be directly related to industrial water conservation, it represents an example of water reuse. An atmosphere of cooperation now exists between industrial water users and the utilities that serve them. In many parts of Texas, both parties are working toward more efficient use of water.

A New Regulatory Paradigm

As industries and governmental entities seek common ground and unite in the drive toward more efficient water use, one important hurdle must still be crossed. As they strive to fully implement water reuse, recycling, and conservation technology, industries need to know their "lives" will not be made infinitely more uncomfortable by additional government regulations. Specifically, they want to know if their existing discharge permits will be revisited by the government. Sometimes, conserving water in an industry can cause some level of degradation in the discharge waste stream. For example, industries may be able to conserve water, but in so doing, they may accelerate a build-up of salts and minerals. As salts and minerals build up, they may have an effect on the receiving stream. The question from a regulatory point of view is whether that effect is highly localized, or whether it is impacting the overall stream health. Existing permit regulations speak specifically to whatever comes through the discharge pipe, and not necessarily to overall stream integrity. If the nature of the discharge from the pipe changes, the permit must be revised.

Industries say they are not arguing that regulations are unnecessary or that they are not needed for significant changes in effluent quality and quantity. They even say that they wouldn't mind having their permits revised -- if it did not always mean costly special studies and reviews. Presently, many industries identify water conservation measures that would be economically feasible to implement, but fail to do so because a costly re-examination of their permits may be required. Many industries feel that the fear of the repermitting process often has an impact on conservation plans, even good ones (*Shifly, Betz Industrial*, personal communication). Companies are afraid to ask the State to review conservation plans for fear of the need to repermit. Often, implementing water conservation measures can be intimidating for industries if it means going through a cumbersome permitting process again (*Shifly, Betz Industrial,* personal communication, 1994*; Hoffman, TWDB,* personal communication, 1994).

Texas governmental agencies are increasingly aware of regulatory impediments to industrial water conservation, and are searching for ways to provide incentives for conservation that are environmentally sound (*Hoffman, TWDB,* personal communication, 1994). A good portion of the first generation of environmental regulations were reactive and punitive in nature; they were designed to "deal" with pollution in terms of punishment and abatement.

Today, recognition of the need for a new paradigm is emerging (*Hoffman, TWDB*, personal communication, 1994). Industries and government agencies in Texas are searching for better ways to streamline and encourage water conservation while still protecting the environment.

For More Information

Hoffman, H. William, 1993, "Industrial Water Conservation and Reuse in Texas: The Big Picture," *Watertech `93*, pp. 82-87.

Pequod, 1993, *Industrial Water Use Efficiency Study*, Report Submitted to Texas Water Development Board.

Camacho, Robert, 1993, "Usage of High Volume of Water by High Tech Companies," presentation to the City of Austin Water and Wastewater Commission.

Anderson, Beauford, 1993, "Commercial and Industrial Program Case Studies," *in Proceedings of Conserve* `93, pp. 485-517.

Editor's Note

The Texas Water Resources Institute has just begun publishing a new newsletter series focusing on water conservation issues titled *Texas Water Savers*. The first issue of the newsletter has just been published. To receive a copy, to be placed on the mailing list, or to find out how you can help sponsor the newsletter, call TWRI at (409) 845-8571.

Sincerely,

Ric Jensen, Info. Specialist, TWRI

New Technical Reports, Newsletters, Available from TWRI

The Texas Water Resources Institute has recently published the following technical reports: *Water Rights Analysis Package, Model Description and Users Manual* (TR 146), *Effectiveness of Native Species Buffer Zones for Nonstructural Treatment of Urban Runoff* (TR 156), *Farmers, Lenders and Water Districts Response to Texas Low Interest Loan Program for Agriculture* (TR 164), *Reservoir and River System Reliability Considering Water Rights and Water Quality* (TR 165), and *Water and Solute Flow in a Highly Structured Soil* (TR 161). TWRI is also publishing three other newsletter series: *New Waves*, *On-Site Insights*, and a new publication that focuses on urban, residential and industrial water conservation titled *Texas Water Savers*. Any of these publications can be ordered free by contacting TWRI.