HYDROLOGY AND WATER RESOURCES IN ARIZONA AND THE SOUTHWEST, VOLUME 8, p. 115-119.
Proceedings of the 1978 meetings of the Arizona Section of the American Water Resources Association and the Hydrology Section of the Arizona Academy of Science, held in Flagstaff, Arizona, April 14-15.

WASTEWATER EFFLUENT - AN ELEMENT OF TOTAL WATER RESOURCE PLANNING

by

James D. Goff, P.E.[1]

ABSTRACT

Wastewater reuse options for the Phoenix area include: agricultural irrigation, fish and wildlife enhancement, ground water recharge, industrial processing and colling water, recreation, cooling water for power generation stations, and exchanging effluent for additional water supplies. Consideration is given to effluent reuse potential as a commodity to exchange for water suitable for domestic water supply. This exchange would result in yet additional reuses of the water as title to the effluent could be assured by contracts and agreements.

INTRODUCTION

Background.

In Arizona, water is a scarce and valuable commodity. Therefore, the reuse and conservation of this resource takes on a particular significance. The first record of recycling of treated wastewater in Arizona was in the 1920s at the Grand Canyon. Water was obtained from springs at the bottom of the Grand Canyon and at times the domestic water supply was in short supply, therefore, recycling and conservation was a necessity. The railroads serving the Grand Canyon used steam locomotives, and treated wastewater was used by these railroad engines. In addition, the high quality effluent was also used in the lodges to convey domestic wastes to the treatment plant.

Recent reuse applications.

More recent examples of effluent utilization include the City of Prescott which irrigates the Antelope Hills Golf Course with effluent from the municipal wastewater treatment plant. The City of Tucson has sold effluent to cotton growers. A planned community near Scottsdale, Fountain Hills, was planned to reuse wastewater by turf irrigation for use on golf courses and greenbelts.

Phoenix area reuse.

Around 1932, Phoenix constructed its first modern wastewater treatment plant near 23rd Avenue at the Salt River. The effluent was discharged into the Salt River, which was normally dry. Downstream agricultural interests soon started diverting water from the river bed to use for agricultural purposes and several still follow this practice today.

The Phoenix Water and Sewers Department has been interested in wastewater reuse for almost half a century. As the City of Phoenix and other communities grew, the far-sighted thinking of the community officials recognized that wastewater would someday be the largest single water source. The wise use of this water resource is a major factor in solving the water supply needs for Metropolitan Phoenix. In the Phoenix Metropolitan area there is a definite potential for the direct reuse of municipal wastewater. Several agreements and contracts presently exist for these purposes. Various other reuse options are being studied by the Corps of Engineers in conjunction with the 208 wastewater management planning effort currently being conducted by the Maricopa Association of Governments.

EFFLUENT REUSE OPTIONS

Agricultural irrigation.

The utilization of wastewater effluent for agricultrual irrigation purposes is feasible in the Phoenix Metropolitan area. There are presently in excess of 200,000 acres (80,940 hectares) of agri-

[1]Senior Engineer, Boyle Engineering Corporation, Phoenix, Arizona, 85016

cultural land, and at an average irrigation use rate of 5 feet (1.5 meters) per year, there is a potential demand for over one million acre-feet (1234 x 10^6cubic meters) or irrigation water annually. There are a number of water districts located within the Phoenix area which operate groundwater supply systems and distribute appropriated surface water in the urban and agricultural areas. The State has established rules and regulations controlling the use of effluent from wastewater treatment plants for a variety of uses including agriculture. Effluent which has received at least secondary treatment can be used for: irrigation of fibrous or forage crops not intended for human consumption; irrigation of orchard crops by methods which do not result in direct application to the fruit or foliage; and watering of farm animals other than producing dairy animals.

If the secondary treatment is followed by disinfection, the uses permitted by the State are: irrigation of any food crop where the product is subjected to physical or chemical processing sufficient to destroy pathogenic organisms; irrigation of orchard crops by methods which involve direct application; and watering of producing dairy animals. Effluent that has received secondary treatment followed by tertiary treatment plus disinfection can be used for irrigation of food crops which may be consumed in their raw or natural state. A discussion of various possibilities follows:

The reuse of wastewater for agricultural use is not without its logistical problems, since the pattern of flows discharged from treatment plants is in disparity with agricultural needs. The diversion of water to irrigated agriculture is not constant during the year. Rainfall, temperature, and type of crops grown cause variations. There will often be times when the treatment plant effluent will be discharged elsewhere if the treatment plant is intended to supply one hundred percent of irrigation needs. The portion of effluent not directly taken for crops could be surface stored in lakes for later use, artificially recharged to underground storage, wasted down a watercourse, or otherwise utilized. Conduits for conveyance, pumping stations, storage reservoirs, and like aspects relating to effluent transportation use and disposal must be studied for economic feasibility when definite offerings are made to contract for the wastewater.

It is a difficult task to pinpoint and identify specific locations where highly treated effluents can be discharged and accepted without interfering with present water supply uses and facilities. For instance, delivering effluent into the Arizona Canal would create some problems since this canal is on the major raw water source for two Phoenix water plants and soon to be built Glendale water treatment plant. Perhaps a discharge point downstream of the Glendale plant location would be an acceptable location, or the Southern Canal below the Val Vista Water Plant location.

The Roosevelt Irrigation District has an agreement with the City of Phoenix to use a maximum of 20,000 acre-feet (25 x 10^6 cubic meters) of effluent annually for "unrestricted" agricultural use. The agreement stipulates that the City must provide additional treatment to the secondary effluent, consisting of percolation and subsequent pumped withdrawal, so as to produce reclaimed wastewater suitable for unrestricted agricultural use. It should be noted that problems with power cost of pumping the reclaimed water have risen, and this agreement has not, to date, been implemented. This agreement does, however, set a local precedent and the use of reclaimed wastewater for unrestricted irrigation contains some important implications. One such implication is that if a sufficient quantity of reclaimed water could be produced in a quality suitable for "unrestricted" agricultural use, then existing canal networks could deliver water downstream of water treatment plants, and they can be an economical and available means of transporting the effluent to the application sites. This distribution method would allow the effluent to be more widely distributed, lessening the problem of seasonal demand fluctuations. The final consideration concerning the agricultural use of municipal wastewater effluent is cost. The cost to the user for reclaimed wastewater, including all power, transportation and other related costs, must be competitive with other available waters in the area or it will not be purchased.

Recreation.

Treated municipal wastewater can, under certain conditions, be successfully used for recreational purposes. The Phoenix area offers many opportunities for recreational reuse of effluent. Leisure World, a planned development community, has a 15-acre lake which presently is supplied water mainly from wells and surface run-off, however, ultimate plans call for the lake to be fully supplied by municipal effluent. The lake is used primarily for aesthetic purposes and also serves as an emergency reservoir for fire protection. The lake has been in use for about three years. The proposed Rio Salado Project, which would be located in central Phoenix, would create numerous recreational lakes and impoundments along the course of the Salt River. Many of these impoundments could be kept filled either partially or totally with municipal wastewater effluent. The community of Sun City, located northwest of Phoenix, presently operates 63 acres of aesthetic and recreational lakes, offering a further potential for effluent reuse. Further opportunities for municipal wastewater effluent reuse are application to any of the natural dainage-ways in the area including the Upper and Lower Indian Bend Wash, the Cross-cut Canal, and the Agua Fria, Gila, New and Salt Rivers.

Cost must, of course, be a consideration in recreational reuse of effluent. On a site-specific basis, additional treatment, land acquisition and development, and operation and maintenance costs must be considered. Public acceptance of a recreational lake using wastewater effluent is a factor that must be weighed on a site-specific basis.

Fish & Wildlife Enhancement.

The use of reclaimed wastewater for fish and wildlife enhancement is very closely related to recreational reuse and much of the same criteria is applicable. Man-made lakes created for recreational purposes can also be stocked with fish to expand the use of the body of water to include fishing as a means of recreation.

Turf Irrigation.

Extensive use is currently made of wastewater effluent on golf courses and parks throughout the area. The following six areas in Metropolitan Phoenix utilize wastewater effluent to irrigate parks, greenbelts, and golf courses: Apache Wells, Carefree, Fountain Hills, Leisure World, Williams Air Force Base, and an area served by Sonny Boy Sewer Company. As an example of how the use of effluent could effect savings in domestic water Sun City Water Company reports that water usage for park areas, lakes, and public areas is equal to the amount of water used for domestic purposes. A study conducted by the University of Arizona Agricultural Experiment Station on the Consumptive Use of Water by Crops in Arizona has determined that Bermuda grass, the most prevalent turf in the Phoenix area, has a seasonal consumptive water use of 43.5 inches (110 centimeters) between mid April and mid October.

The Arizona Department of Health Services regulations for use of wastewater effluent require that secondary treatment and disinfection be performed prior to irrigation of golf courses, cemetaries or similar areas; and secondary and tertiary treatment plus disinfection be provided to effluent used to irrigate school grounds, playgrounds, lawns, parks, or other areas where children are expected to congregate or play.

Industrial Cooling Water.

It is estimated that by the year 1980, industry nationwide will utilize 75,026 million gallons (283×10^9 liters) of water daily and consume about 6,126 million gallons (23×10^9 liters) per day. This represents seventeen percent of all the nation's water requirements and six percent of all consumption. A major portion of this water is used for cooling purposes for which, in many cases, potable quality is not necessary. An average of sixty-six percent of the total water used by industry nationally is for cooling. There are; however, only a few industries located in the Phoenix Metropolitan area that utilize large amounts of potable water for cooling purposes.

Industrial Processing Water.

Approximately one-third of all waters used by industry nationally is used as process water. Process water in selected industries is often required to be of higher quality than domestic potable water. Tertiary treatment processes such as lime coagulation, clarification and settling, followed by sand filtration, could provide needed treatment. In addition to the variations in quality requirements, quantity also varies substantially from one industry to another. Water requirements for industry are often related in one form or another to the product being produced.

The use of reclaimed secondary effluent, exclusive of further treatment, for major industries in Phoenix could entail the construction of many miles of additional pipelines and pumping stations to transport the reclaimed water to the point of use. In addition, internal plant piping would have to accommodate the use of non-potable water in some processes while preventing cross connection with the potable water necessary for other operations. Industrial process use of effluent could become feasible only when: the industry is located reasonably close to the treatment facility; the quality of the effluent is acceptable to the industry; and the total cost of the effluent, including transportation and possible additional treatment is comparable with other available water sources.

Groundwater Recharge.

In the Phoenix Metropolitan Area there are at least two examples of controlled groundwater recharge with effluent. The City of Mesa Wastewater Treatment Plant discharges its effluent ostensibly for agricultural irrigation. A major portion of this effluent, however, percolates into the ground. The Arizona Public Service Ocotillo Power Generation Station, in turn, pumps this effluent from the ground for use as cooling water in the plant. As it passes through the soil and is pumped by the generation station, the effluent has received sufficient treatment to be adequate for the generation station's cooling system needs. Another example of controlled groundwater recharge in the Phoneix area is at the 23rd Avenue Wastewater Reclamation Project. The effluent is imparted to the groundwater aquifer by the use of several recharge basins. The Roosevelt Irrigation District has contracted with the City of Phoenix for the future pumping of this groundwater for "unrestricted" agricultural use. The depletion of quality groundwater reserves in the area is a constant problem, and every effort must be made to return good quality water to the ground. Engineered, controlled recharge with municipal wastewater effluent is certainly a feasible alternative.

Cooling for Energy Production.

The highest feasible reuse option for municipal wastewater effluent is in the area of cooling water for the production of energy. Approximately 35 miles west of the Multi-Cities Wastewater Treatment

Plant, effluent is scheduled to be used as condenser cooling water in the Arizona Nuclear Power Project (ANPP) which is presently under construction.

A study was made by the ANPP of the availability of the quantity and quality of groundwater in the area. The high volume of water needed coupled with the possibilty of subsidence and the lowering of the water table led to the search for an alternative dependable source of water. The search naturally looked to the City of Phoenix wastewater effluent, which is a large, dependable source of water of relatively good quality. It is estimated that the total amount of make-up water needed per year will be 25,266 acre-feet (31 X 10^6 cubic meters) per generating unit or a total of 75,800 acre-feet (94 X 10^6 cubic meters) per year for three units. All of this water can be supplied from the Phoenix Metropolitan Area Wastewater Treatment Plants.

The practicality of using treated wastewater effluent for this purpose becomes most apparent when the quantity required is considered. The generation station will ultimately use an estimated 75,800 acre-feet (94 X 10^6 cubic meters) of cooling water annually. The ANPP plans to use the total contracted amount of effluent of 140,000 acre feet (173 X 10^6 cubic meters). The use is projected to be for additional generating units at the Maricopa County generating station site or possibly other sites. The generation station requires this water on a continued, assured basis. For this reason, and due to its relatively close proximity to the Phoenix Multi-Cities Wastewater Treatment Plants, the use of municipal wastewater effluent for energy production cooling purposes becomes the most logical and feasible option for effluent reuse in the Phoenix area.

In the cooling cycle of energy production, the water will be totally consumed or evaporated and the only by-product will be the solids which will be collected in evaporation ponds. A further consideration would be the possiblity of providing some interim, non-consumptive use of the effluent prior to its arriving at the ANPP site. The Multi-City-ANPP agreement allows contractual sale of effluent by Phoenix and to other parties, provided appropriate recapture provisions are included to enable ANPP to obtain the effluent as their needs dictate. The Roosevelt Irrigation District contract is an example of such interim sale.

TRADE/EXCHANGE OF EFFLUENT

Trading Wastewater For Water Supply.

The large quantities of wastewater presently available and likely to be available in the future makes this the largest potential. Such a program, however, will take coordinated planning and supplementary funding, as well as the cooperation from several agencies. Without this cooperation, this alternative may not be possible at all. Several elements will have to be included and agreement reached. As an example, to trade effluent for water used by agriculture; the following actions and conditions are minimal:

(1) Quality must be acceptable to State and County Health Departments for intended use and acceptable to the Salt River Project (and irrigators). Upgrading of quality will probably be necessary.
(2) Agreement as to the discharge (receiving) point.
(3) Agreement as to quantity of deliveries and dates (schedule monthly and seasonally).
(4) The exchange for potable water must have the provision to use the potable water anywhere off-project without restriction similar to the rights of use of the effluent.
(5) The Salt River Project Operating Agreement or Water Contract would require modification to provide for accounting of water credits.
(6) Construction of upgrading facilities including the pumping station and force main if needed.

It is possible that an agreement and trade for effluent could be worked out between the Multi-Cities and Salt River Project for discharge into the Grand Canal near its heading at about 40th-48th Street or some closer canal location. The Grand Canal is the only major canal in the Phoenix area that does not deliver water to a water treatment plant. Care should be exercised in the plans to discharge even disinfected and treated effluent into locations upstream of water plants. The Salt River Project and all the municipalities in the Valley have to be involved in any such alternative that might be developed.

A similar alternative might be arranged between the Salt River Project and the St. John's Irrigation District with upgraded 91st Avenue Plant effluent. The St. John's Irrigation District lies southeast of Avondale and has head works and canals near 91st Avenue. The district diverted water in the early days from the flowing Salt River before upstream dams were built. Now most surface water diversions have been replaced by wells operated by the Salt River Project, and is essentially Project water exported off-project. The St. John's District use about 10 MGD.

The Roosevelt Irrigation District (RID) obtains water from several wells as part of a commitment made by the Salt River Project many decades ago to furnish water for use outside the "Project". The impetus given to this arrangement was a general water logged condition of the soil in the Phoenix area. Drainage wells were drilled and operated for the purpose of lowering the water table, and canals were built to carry this water away and for use on lands outside the Salt River Project. The Roosevelt Irrigation District continues to operate these wells but is limited contractually to 145,000 acre feet per year as averaged over any 5-year period. There is a possiblity for an exchange agreement whereby

the City of Phoenix would furnish upgraded effluent to the RID and in return the RID were to agree to cease pumping Salt River Project groundwater for off-project use in like amounts. The Salt River Project would then agree to allow the City of Phoenix to pump Project water (including groundwater) to areas served "off-Project".

An examination of most of the contracts between Phoenix, the Multi-Cities, and the purchasers of effluent, (ANPP and RID) reveals a provision that the Cities have the right to recapture such effluents "out from under" the contractual obligations, during times of water shortages and for the purpose of solving domestic water shortages. These provisions have been made publicly for the past 15 years and documented in several recent reports.

The primary and most important purpose in the management of wastewater effluent is planning the use of a commodity that can be utilized to enhance the Phoenix and other municipalities' long range public water supply. It is good water management policy to use wastewater flows to solve the valley's future water supply problems. Studies that involve water balances indicate wastewater will have to be utilized as part of the total water picture. If new uses are initiated for wastewater, then the water shortage will be even more severe.

The Exchange Concept.

The Salt River Project has long standing commitments permitting exportation of water for irrigation. Therefore, it appears logical to use the treated wastewater effluent in an exchange arrangement. The Exchange concept is the substitution of treated wastewater for "fresh" water in irrigation practice with "fresh" water credit being given for the wastewater. The exchange wastewater could be used for on-project or off-project. Exchanges would not necessarily be confined only to export commitments; wastewater deliveries could be made for agricultural purposes within the Salt River Project boundaries as well. Export commitments are on the order of 2000,000 acre feet per year. By the year 2000, as much as 300,000 acre feet per year of wastewater can be expected to flow to valley treatment plants. The exchange concept, of course, implies an existent control of wastewater and "fresh" water by different entities; in this case the Salt River Project has the export commitments and control of the Salt-Verde surface waters; the Maricopa Water District has control of the Agua Fria surface water; and the cities of the Valley Multi-Cities Agreement collect and treat the wastewater.

CONCLUSIONS

Municipal wastewater effluent is a resource, and controlled reuse can be planned in the interest of increasing the future public water supply. Close cooperation is needed among all who would participate in this concept. Wastewater collection and treatment has traditionally been characterized as a local responsiblity. Because of the economics of construction and operation of treatment facilities, this characterization has begun to change to a more regional concept. Wastewater, when treated adequately, can become a future water supply by exchange agreements. The exchange concept is the substitution of treated wastewater for "fresh" water used in irrigation practice with "fresh" water credit being given for the use of wastewater. The exchanged wastewater could be used on-project or for off-project commitments; the exchanged "fresh" water could also be used both on-project and off-project.

ACKNOWLEDGEMENT

Appreciation is extended to Art Vondrick, Director, Phoenix Water and Sewers Department who has been prominent in emphasizing and promoting certain effluent exchange concept and provided much of the data for the compilation of this paper. Thanks is also extended to the U.S. Army Corps of Engineers, Phoenix, Urban Study whose publication "Potential Reuse Options for Wastewater Effluent and Residual Solids", June 1977, was the source of much of the reuse alternatives described herein.