Free, Untapped Water For Irrigation in Humid Regions

Introduction

Humid regions have an untapped water source that is virtually free and unrestricted during drought. Air conditioning produces large amounts of condensate ideal for landscape irrigation. This water is reliable, clean and is produced when irrigation demand is high. Large buildings send millions of gallons of condensate to sewers and storm drains. Changing this practice is simple during design, but can also be achieved through retrofits.

The amount of condensate water produced in San Antonio is surprising. A shopping mall measured their June collection from seven air handlers at 2.5 gallons each minute. The downtown library easily fills their 26,000 gallon system at a one gallon/minute collection rate. These high yields provide a quick payback for the small investment needed to harvest condensate water.

Condensate Recovery Manual Draft

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This session will review design and cost/benefit analysis steps outlined in the Draft San Antonio Water System Condensate Recovery Manual produced by Eddie Wilcut and Brian Lilibridge of San Antonio Water System. To provide feedback contact Eddie or Brian at ewilcut@saws.org.

Condensate 101

Simply put, **condensation** is the process by which water vapor turns from a gas state into a liquid state. Consider what happens when you set a glass of ice water outside on a warm, sunny day. The temperature of the outside air is higher than the temperature of the surface of the glass. As the water vapor in the air surrounding the glass cools down it changes from a gaseous state to a liquid and the glass appears to sweat. This “sweat” is actually condensate forming on the surface of the glass. The same effect can be seen in the winter when condensate forms on the inside of windows.

A few other related terms that might be helpful in understanding the process of condensation are “absolute humidity”, “relative humidity”, and “dew point”. **Absolute humidity** is the total amount of moisture that air can hold at a given temperature. **Relative humidity** is given as a percent value and indicates the amount of moisture air contains in relation to the absolute humidity. When your local meteorologist refers to humidity during the forecast, they are actually talking about relative humidity. Another staple in most weather forecasts is the dew point. The **dew point** is the temperature at which water vapor condenses out of the air and forms moisture on the ground and other surfaces outside. As air cools, it's ability to hold water in the form of vapor decreases. The dew point is reached when the air temperature cools sufficiently in relation to the absolute humidity to allow dew to form. These same principles that cause condensate to form on the glass of ice water or windowpane and dew to form on the grass are responsible for the generation of condensate by air conditioning equipment.

Air Conditioning System Basics
Air conditioning systems vary in size and configuration. But whether it is a small window unit, a 5-ton system used for a single-family residence, or a 1,000-ton system used at a manufacturing facility, the process of conditioning air is basically the same. Single-family residences and many businesses can be effectively cooled by a **split-system** where the condensing unit is placed outside and the air handler is located inside the structure. Very large or multi-story facilities may require a different type of system that uses chilled water instead of a refrigerant gas.

In a split-system, the **condensing unit** contains a compressor, exhaust fan, and condenser coils. A refrigerant gas is compressed and ran through the coils where it is condensed into a liquid. Once in liquid form, the refrigerant is passed through an expansion valve where it evaporates back into a gas and in the process, cools rapidly. The chilled gas is then run through another series of coils (the **evaporator**) inside the building where it absorbs heat from the surrounding air. The evaporator along with a ventilation fan make up the part of the A/C system often referred to as the **air handler**, and this is where condensation occurs. As the fan pushes the warm, moisture-laden air over the evaporator, the water vapor condenses out and accumulates on the coils. The condensate is collected in a drip tray where it is usually drained to the outside of the structure or into the sanitary sewer. But as you will see in the following sections, the reuse potential for condensate makes it much too valuable to simply be drained away.

Condensate Production in Commercial/Industrial Facilities

Influencing Factors
Facility managers may question whether their facility can produce enough condensate to make collecting it a cost-effective venture. Homeowners that have had the misfortune of having their home partially flooded by a blocked condensate line have seen first-hand the potential of condensate production in our area. The average residential air conditioning system can produce anywhere from 5 to 10 gallons of condensate a day. It is not hard to realize the potential of industrial air conditioning systems to produce large amounts of condensate. Several factors will determine how much condensate can be produced by a facility, but some of the predominant ones are weather, industrial processes/human factors, and cooling capacity.

Weather
San Antonio experiences an abundance of warm, sunny weather. In the winter, 50 percent of the days are sunny and in the summer that figure increases to 70 percent. In fact, this area averages over 300 sunny days annually. Maximum daily temperatures during the summer are above 90 degrees over 80 percent of the time.

San Antonio Weather Statistics

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Median Temperature (deg. F)	Max.	60.8	66.2	73.4	80.6	86.0	91.4	95.0	95.0	89.6	82.4	71.6	64.4
	Min.	37.4	41.0	50.0	59.0	66.2	73.4	75.2	75.2	69.8	59.0	48.2	41.0
	Mean	50.0	53.6	62.6	69.8	75.2	82.4	84.2	84.2	78.8	69.8	60.8	51.8
Amount of Sunshine	hrs/mon.	159	170	216	210	222	276	309	294	235	218	172	150
Relative Humidity (%)	Morning	80	80	79	82	87	88	86	85	85	84	81	80
	Afternoon	60	58	56	58	61	59	54	53	56	56	58	59

In addition to that, San Antonio enters a sub-tropical weather pattern in the summer. The relative humidity is highest in the early morning and decreases as temperatures warm up during the day. The average relative humidity in San Antonio humidity ranges around 50% in the late afternoon. That's not as much as our neighbors to the east- Houston's average relative humidity ranges around 63% in the afternoon. But it's still a substantial amount of moisture in the air, and it makes a hot day feel even hotter. The result of all of these climatic factors combined is that air conditioning equipment must operate constantly throughout the day in order to meet the requirements of most industrial/commercial facilities.

Industrial Processes/Human Factors
Condensate production will also be greatly influenced by the manufacturing processes and human activities that occur within a facility. Computers, copy machines, and other office necessities as well as lighting, and manufacturing equipment all introduce heat into the working environment. Manufacturing processes such as sterilization or food preparation that generate large amounts of steam and heat will increase the potential for condensate production by introducing added moisture in the air. Also, certain working

environments like clean rooms require a closely controlled humidity. These situations require A/C equipment to worker harder and run longer to maintain specific working environments and therefore lead to increased condensate production.

Large-scale facilities that are not used for manufacturing can still produce a useable amount of condensate. Human activity alone can dramatically influence the potential for condensate recovery. Facilities that experience a high amount of foot traffic have large amounts of outside air continually brought inside, causing increases in the indoor temperature and humidity. Human respiration and body heat also increase indoor temperature and humidity. While seemingly insignificant on an individual basis, the heat and moisture generated by a large number of people can significantly affect indoor air characteristics.

Cooling Capacity

A facility's cooling capacity plays perhaps the most direct role in condensate production. Systems with a higher rated tonnage and load factor will produce condensate in greater amounts. **Tonnage** is a measurement that relates a system's cooling capacity to the equivalent cooling effect of melting ice. For example, a system rated at 2 tons can produce the same amount of cold air as melting two tons of ice per hour. Also, air conditioning systems are seldom operated at full capacity. The **load factor** is a ratio of the average system load over a certain period of time to the maximum rated capacity of the system. Multiplying the tonnage by the load factor gives an indication of the actual amount of cooling a system is doing. In effect, a 1,000-ton system operated at a load factor of 70% is equivalent to a 700-ton system operating at 100%.

Estimating Condensate Production

Although numerous factors influence condensate production, most large facilities in this area can expect to produce around 0.1 to 0.3 gallons of condensate for every hour the cooling system is operated. This range is based on measurements taken at several large facilities around San Antonio. It is best to use 0.2 gallons per hour to provide a conservative estimate of condensate production for planning purposes. To calculate condensate production for a specific system multiply tonnage, load factor, and .02 gallons. For example:

1,000 tons X 70% load factor X 0.2 gallons = 140 gallons per hour

The following chart provides condensate estimates for a variety of system sizes and load factors:

ESTIMATED GALLONS OF CONDENSATE PRODUCED PER TON HOUR OF OPERATION

LOAD FACTOR (%)	CONVERSION FACTOR**	COOLING EQUIPMENT TONNAGE										
		50	100	200	300	400	500	600	700	800	900	1000
50	0.1	2.5	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
	0.2	5.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0
	0.3	7.5	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0
55	0.1	2.8	5.5	11.0	16.5	22.0	27.5	33.0	38.5	44.0	49.5	55.0
	0.2	5.5	11.0	22.0	33.0	44.0	55.0	66.0	77.0	88.0	99.0	110.0
	0.3	8.3	16.5	33.0	49.5	66.0	82.5	99.0	115.5	132.0	148.5	165.0
60	0.1	3.0	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0
	0.2	6.0	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0
	0.3	9.0	18.0	36.0	54.0	72.0	90.0	108.0	126.0	144.0	162.0	180.0
65	0.1	3.3	6.5	13.0	19.5	26.0	32.5	39.0	45.5	52.0	58.5	65.0
	0.2	6.5	13.0	26.0	39.0	52.0	65.0	78.0	91.0	104.0	117.0	130.0
	0.3	9.8	19.5	39.0	58.5	78.0	97.5	117.0	136.5	156.0	175.5	195.0
70	0.1	3.5	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	63.0	70.0
	0.2	7.0	14.0	28.0	42.0	56.0	70.0	84.0	98.0	112.0	126.0	140.0
	0.3	10.5	21.0	42.0	63.0	84.0	105.0	126.0	147.0	168.0	189.0	210.0
75	0.1	3.8	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0
	0.2	7.5	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0
	0.3	11.3	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0
80	0.1	4.0	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0
	0.2	8.0	16.0	32.0	48.0	64.0	80.0	96.0	112.0	128.0	144.0	160.0
	0.3	12.0	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0
85	0.1	4.3	8.5	17.0	25.5	34.0	42.5	51.0	59.5	68.0	76.5	85.0
	0.2	8.5	17.0	34.0	51.0	68.0	85.0	102.0	119.0	136.0	153.0	170.0
	0.3	12.8	25.5	51.0	76.5	102.0	127.5	153.0	178.5	204.0	229.5	255.0
90	0.1	4.5	9.0	18.0	27.0	36.0	45.0	54.0	63.0	72.0	81.0	90.0
	0.2	9.0	18.0	36.0	54.0	72.0	90.0	108.0	126.0	144.0	162.0	180.0
	0.3	13.5	27.0	54.0	81.0	108.0	135.0	162.0	189.0	216.0	243.0	270.0
95	0.1	4.8	9.5	19.0	28.5	38.0	47.5	57.0	66.5	76.0	85.5	95.0
	0.2	9.5	19.0	38.0	57.0	76.0	95.0	114.0	133.0	152.0	171.0	190.0
	0.3	14.3	28.5	57.0	85.5	114.0	142.5	171.0	199.5	228.0	256.5	285.0
100	0.1	5.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0
	0.2	10.0	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
	0.3	15.0	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0	300.0

**The conversion factor will vary based on location and site conditions.

Reusing Condensate

Water Quality

Condensate is a high quality source of water, making it ideal for numerous applications. Because of the removal of minerals during the evaporation process, condensate is similar in water quality to distilled water. In condensate, suspended solids, turbidity, and salinity are low and the pH is neutral to slightly acidic. It is important to keep air-conditioning equipment as clean as possible in order to ensure that condensate stays uncontaminated In particular, the evaporator coils and drip trays should be kept free of dust, dirt and other debris since the condensate comes in direct contact with their surfaces.

One concern that deserves special attention when dealing with condensate is the possible presence of microbial pathogens. If condensate is allowed to stagnate and become warm in a cooling system, it can lead to favorable growth conditions for the *legionella pnuemophila* bacteria that is the cause of Legionnaires' disease. Although legionella pnuemophilia is commonly found in a variety of natural and man-made aquatic environments, it can become a public health threat if water containing the bacteria is atomized and inhaled. Outbreaks of Legionnaires' Disease have been traced to poorly maintained cooling towers, but the bacteria can be easily controlled by several commercially available biocides.

Methods of Collection

With careful planning, collecting and reusing condensate is an easy process. The materials used to construct a condensate collection system are readily obtainable and easy to assemble. The three main components of a condensate collection system are collection piping, a storage tank, and a method of delivery to the point of reuse- this can be achieved by gravity or a pump. Incorporating a condensate collection system into the design of a new facility will significantly lower the cost and decrease the time it takes the system to pay for its self. Air handlers can be positioned in such a way that gravity can be used to move the condensate to storage tanks or nearby cooling towers. It is also important to maintain easy access to the condensate drip trays so that they can be cleaned regularly.

Considerations for Irrigation

The water produced by condensate from cooling processes is clean. However, it easily picks up contamination from drip pans and other surfaces. The same would be true for rainwater collected from a roof. ANY water stored for more than a few days should be considered a potential hazard and treated accordingly before public contact.

Irrigation systems in public areas are one potential way for people to come in contact with water from a collection tank. If water is applied through drip irrigation, there is very little potential for human contact with the water and not much reason for concern. However, if water will be sprayed through traditional spray heads it is necessary to consider a biocide process. Options can be as simple as regularly dropping pool chlorine tablets into a tank. Pool equipment that automates chlorination is even more convenient.

There are pool equipment devices that allow chlorine tablets to be added and then circulated periodically into the tank. This adds slightly to the cost of the condensate project because the chlorination device and a pump are added. However, the payback and peace of mind that the water is safe are worth the investment.

Case Studies

Sony Semiconductor, San Antonio, Texas
In 1999, Sony Semiconductor began construction on a system to collect condensate from three outside air handlers. The project involved the routing of condensate from three outside air handlers through a system of pipes connected to cooling tower make-up lines. The construction involved installation of new piping and three return pumps. This system also incorporated an in-line meter, to allow for the tracking of water savings.

The average monthly cooling tower usage is 2,700,000 gallons. The potential average monthly condensate collected by this system equals 155,940 gallons or 1,871,000 gallons per year.

Based on a $5,777.00 investment and financial savings of $4,371.08 per year, the simple payback period was calculated at 16 months.

San Antonio Public Library Alternative Irrigation Project
In 2002, the San Antonio Library began work on a new 26,000 square foot educational garden. In order to further the educational impact, it was suggested that a rainwater harvesting system be considered. San Antonio Water System's (SAWS) Conservation Department was contacted for assistance in evaluating the effectiveness of installing a rainwater harvesting system. As a result, Conservation Planners evaluated the potential based on such factors as the type of landscape, evapotranspiration, annual rainfall, storage requirements and cost.

Because rainfall events in Texas can often be sporadic, it is important to size an effective rainwater harvesting system with sufficient storage capacity to collect enough water during rain events and store it until those months when little or no rainfall is received. For example, if one were to assume median rainfall during the month of July in San Antonio, TX, a rainwater harvesting system for a 26,000 square foot landscape would need to employ approximately 26,000 gallons of storage capacity. For this reason, rainwater-harvesting systems, within urban settings such as San Antonio, TX, are not usually cost effective measures.

As an alternative, Conservation Planners also evaluated the potential for condensate collection. The potential was determined simply by locating the building's condensate drain and recording collection readings over span of several days. Based on collection data, it was determined that the building's air conditioning system was producing condensate at the rate of one gallon per minute (gpm) or 1,440 gallons per day or 43,200 gallons per month.

Based on a complete evaluation, a condensate collection system was designed and constructed. The system incorporates a collection system comprised of three interconnected concrete cisterns with a total storage capacity of 8,400 gallons.

Condensate is pumped into the tanks from a collection sump and is gravity fed into a specially designed irrigation system. The condensate collection system provides all supplemental landscape water even during periods with little or no rainfall. Total cost of the system, including drip irrigation is $21,500.00, an amount that is less than 1/3 of cost of a rainwater harvesting system.

Rivercenter Mall, San Antonio, Texas

In 2002, the Rivercenter Mall completed construction of a condensate collection system capable of capturing condensate water from four large air-handlers. This system incorporates a three-inch drain line system, a 500-gallon collection tank, and a pump for transferring the captured condensate to the cooling towers as make-up water.

An analysis of five years of pre-retrofit consumption data and two years of post-retrofit consumption data reveals average savings of 1.1 million gallons per month or 13.2 million gallons per year.

The significant water savings are a result of a reduction in potable water necessary for cooling tower make-up and increased cooling tower efficiency attributed to the introduction of a water source that has virtually no hardness and is very low in total dissolved solids.

The total installed cost of the Rivercenter Mall system was $32,057.92. Based on water and sewer savings of $49,500.00 per year, the simple payback for this system has been calculated at approximately eight months.

H.E.B. Grocery Company Distribution Center, San Antonio, TX

In 2003, the H.E.B. Grocery Company constructed a condensate recovery system capable of providing boiler feed makeup water in replacement of potable water. The system captures condensate from air-handlers and refrigeration systems, saving more that 6.2 million gallons of potable water each year.

Based on an installed cost of $19,000.00 and financial savings of $20,600.00 per year, the simple payback was calculated at 11 months.

Additional References

- Emory article
- North Carolina article
- UT article