Water Use and Recycling at Texas High Plains Feedyards

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ABSTRACT

Water conservation in the Texas High Plains has become increasingly important as groundwater resources are depleted. A water usage study was performed over a two year period at a 50,000 head beef cattle feedyard. Water usage was correlated to meteorological data from a nearby NOAA weather station. Average daily water usage over the two year period was 10.8 gallons per head per day, which includes water used for drinking, overflow, trough cleaning, evaporation, and feedmill usage. Whenever water trough floats were adjusted for winter conditions, 66% of total usage was used for drinking, 2% was used in the feedmill, and 32% was used for overflow to prevent freezing. Whenever water trough floats were adjusted for summer conditions, 89% was used for drinking, 3% was used in the feedmill, and 7% was lost into the overflow collection system.

Options identified for conserving water included installing more efficient water troughs, repairing existing troughs, or installing an overflow water recycling system. Potential beneficial uses for the overflow water include irrigating crops, sprinkling pens for dust and temperature control, use in steam flaking of grain at the feedmill, or recycling back into the drinking water system. If all of the overflow water were recycled at this feedyard, then 42.7 million gallons (22% of total annual use) would be conserved per year. Construction of a filtration-chlorination water treatment system would have a payback period of 6 years at 8% interest, and would result in a net monthly savings of $707 after payback of the capital investment.

INTRODUCTION

More than 6 million beef cattle are fed each year at feedyards in the Texas High Plains area of the United States (SPS, 1996). As groundwater supplies become more critical in the cattle feeding area of the Texas High Plains, it is important that feedyards and other water users become more aware of water conservation measures. The two main water consumption sources at feedyards are cattle drinking and steam flaking of grain at the feedmill.

Feedyards provide drinking water to cattle 24 hours per day in water troughs placed in each pen, with 50 to 200 cattle per pen typical of most yards. Water is supplied through a pressurized pipeline to a float mechanism that keeps the water in the trough at a constant level. During the winter, there is the potential for ice buildup in the troughs that prevents cattle from access to water and damages plumbing. Several different water trough types have been designed to prevent ice buildup problems. The four most common types used in Texas High Plains feedyards are the standard overflow trough (water flows continuously through the trough when the valve is opened), the temperature-controlled overflow trough (water flows through the trough controlled by a thermostat-type valve), non-overflow trough (electrically heated), and ball-type (floating plastic ball).

In a recent survey of 55 feedyards in the region, 33 feedyards reported using Type 1 standard overflow troughs, eleven reported Type 2 temperature-controlled overflow troughs, six had Type 3 non-overflow troughs, three reported Type 4 ball-type troughs, and the remaining two reported troughs of some other type (TCFA, unpublished data).

Because of the importance of water conservation in the area, a water usage study was conducted at a large feedyard. The objectives of the study were to measure the amount of water used at a typical feedyard, develop relationships for water usage with weather conditions, and identify options for conserving water at feedyards.

Description of the Feedyard

The project was conducted at a feedyard with a one-time feeding capacity of about 50,000 head. The feedyard uses standard overflow water troughs with floats that are adjusted for continuous overflow during the winter (Type 1 troughs). Water is stored on-site in a 750,000 gallon storage tank (large tank) with a pump controlled by the water level in the large tank (Figure 1). The water is pumped from the large tank into the feedyard drinking water supply and feedmill supply system with a pump controlled by the water level in the 30,000 gallon storage tank (small tank). Water usage is metered with a propellor-type flowmeter as it enters the yard.

Each water trough is supplied through a 2-inch diameter pipeline fed from both sides of the feedyard. Overflow from each trough flows into 2-inch diameter drainage pipelines which eventually flow into two 8-inch diameter drain lines and into the stormwater runoff control structure.

Data Collection

The flowmeter at the incoming water supply was monitored daily from November, 1995 through October, 1997 to determine total daily water usage for the entire feedyard. Air temperature was also monitored daily at 6:00 AM and 5:30 PM.

To obtain detailed information on water usage, overflow was monitored over two 72-hour periods, first from April 17-20, 1997 when floats were adjusted for winter conditions, and again on May 9-12, 1997 after the floats were adjusted for summer conditions (Table 1). Overflow at the north overflow pipe was monitored in 20 minute intervals using a polysonic flowmeter. Overflow values measured from the north overflow pipe were adjusted for the entire feedyard. From earlier investigations, it was determined that 90.3% of the total overflow drained to the north discharge pipe and 9.6% drained to the south discharge pipe.

Table 1. Daily Cumulative Overflow Data For 3-Day Periods Measured With Floats Adjusted for Winter or Summer Conditions

	Winter Conditions		Summer Conditions	
	Overflow (gallons)	Total Used (gallons)	Overflow (gallons)	Total Used (gallons)
Day 1	211,003	582,120	47,69	512,820
Day 2	220,056	702,240	45,50	679,140
Day 3	230,924	762,300	44,22	535,920
3 day average	220,662	682,220	45,80	575,960

Water Usage During The Two-Year Period

Because of the large on-site storage tank, which held more than one day's supply of water for the entire yard, there was the potential for no water to enter the feedyard on any day and for large amounts to enter on another day. For this reason, daily water usage for the two year period ranged from 0.0 to 21.0 gal/head/day. Therefore, moving averages were used to smooth the storage volume effect. When five-day moving averages were used, water usage ranged from 4.9 to 16.3 gal/head/day, and for the ten-day moving averages the range was 6.8 to 15.1 gal/head/day. A plot of daily water usage using five-day moving averages is shown in Figure 2. Average daily water usage by month is plotted in Figure 3.

Two water usage peaks were observed per year, one during the winter months and another during the summer months. The peak in the summer was attributed to increased consumption by cattle because of elevated temperatures, while the peak in the winter was because of high overflow rates to prevent ice formation in water troughs.

Total water usage for the two year period averaged 10.83 gal/head/day. Preliminary results from other feedyards suggest water usage ranging from 8.5 to 17.0 gal/head/day. Water usage varies among feedyards because of different water trough types and differing water management practices. For example, some feedyards sprinkle pens for dust control and for cooling of cattle during extremely hot weather.

Water Trough Overflow During Winter and Summer Conditions

Overflow rates ranged from 67 to 223 gpm when floats were adjusted for winter conditions, and 12 to 48 gpm when adjusted for summer conditions (Figure 4). The average overflow rate for the three day period was 153 gpm for winter conditions and 32 gpm for summer conditions. It was apparent that cattle drank the most from 12:00 PM to 4:00 PM, when overflow was the least, and they drank the least at about 6:00 AM in the morning, when overflow was the greatest.

Water troughs are cleaned about every three days during the winter and every two days in the summer. About 11,235 gallons were drained at every cleaning (58 troughs hold 70 gallons, 205 troughs hold 35 gallons), which equated to an average of 3,745 gallons per day during the winter and 5,618 gallons per day during the summer. Using an evaporation rate of 0.2 inches per day and 9 ft^2 water surface area per water trough, then about 300 gallons were lost per day to evaporation. The average daily water usage at the feedmill was 14,752 gallons per day in April and 19,301 gallons per day in May. An average of 0.40 gal/head/day was used in the feedmill based on 12 months of available feedmill water use data.

For the three-day period representing winter conditions, an average of 13.7 gal/head/day was used at the feedyard (water usage measured at pump between large tank and feedyard to minimize storage volume effect). Of this total, 9.0 gal/head/day (65.6%) was used for drinking, 0.08 gal/head/day (0.55%) was used for cleaning troughs, 0.30 gal/head/day (2.16%) was used in the feedmill, 0.006 gal/head/day (0.04%) was lost to evaporation, and 4.33 gal/head/day (31.68%) was attributed to overflow to prevent freezing.

For the three-day period representing summer conditions, an average of 11.61 gal/head/day was used (water usage measured at pump between large tank and feedyard to minimize storage volume effect). Of this total, 10.33 gal/head/day (88.97%) was used for drinking, 0.08 gal/head/day (0.65%) was used for cleaning troughs, 0.39 gal/head/day (3.35%) was used in the feedmill, 0.006 gal/head/day (0.05%) was lost to evaporation, and 0.81 gal/head/day (6.98%) was attributed to leakagelosses into the overflow collection system.

Relationships Between Weather Conditions and Water Usage

Researchers have shown that environmental factors such as temperature, relative humidity, and wind speed influence the physiological effects (heart rate, respiration rate, body temperature, carbon dioxide production) of animals. Temperature humidity indices (THI) have been developed to relate animal heat stress to environmental indicators for several animal species (Buffington et al., 1981; Roller and Goldman, 1969). Water intake in beef and dairy cattle has been related to air temperature (Winchester and Morris, 1956; NRC, 1996), dry matter intake (NRC, 1996), precipitation (NRC, 1996), salinity (Kattnig et al., 1992), dietary salt (NRC, 1996) sulfate concentration (Robertson et al., 1996), and season of the year (Hoffman and Self, 1972).

Regression analyses were performed to evaluate various equations for predicting total daily feedyard water usage based on several meteorological factors. Weather data was obtained from a NOAA weather station located about 30 miles from the feedyard. The following meteorological parameters were collected: daily maximum temperature (°F), daily minimum temperature (°F), daily maximum relative humidity (%), daily minimum relative humidity (%), average daily wind speed (mph), and daily precipitation (inches). Results of the regression analyses for the parameters which were most correlated to water usage are shown in Table 2.

The equation with the best fit was as follows:

$$DWU = 17.63 - 0.317\,T + 0.0034\,T^2 - 0.022\,RH - 0.042\,W + 0.237\,P \qquad r^2=0.60 \qquad [1]$$

where DWU=daily water use (gal/head/day), T=maximum daily temperature (°F), RH=minimum daily relative humidity, W=average daily wind speed, and P=daily precipitation (inches). From the signs of the regression coefficients, it is apparent that water usage increases with temperature as was expected. However, it is difficult to explain the increase in water use with increasing precipitation, or the decrease in water use with increasing

Table 2. Regression Equation Coefficients For Predicting Daily Water Use[1]

r^2	b_0	b_1	b_2	b_3	b_4	b_5
0.417	15.91	-0.272	0.0029	--	--	--
0.597	16.91	-0.315	0.0034	-0.0189	--	--
0.417	15.85	-0.273	0.0029	--	0.0067	--
0.422	15.94	-0.273	0.0029	--	--	-0.081
0.608	17.63	-0.317	0.0034	-0.022	-0.042	0.237

[1]Form of equations: Water Use (gal/head/day) = $b_0 + b_1\,(MAXTEMP) + b_2\,(MAXTEMP)^2 + b_3\,(MINRH) + b_4\,(WIND) + b_5\,(PRECIP)$

minimum daily relative humidity. Water usage also decreased with increasing wind speed, for which the cause is unknown.

A plot of daily water usage vs. maximum daily temperature is shown in Figure 5. There appears to be a strong curvilinear correlation at temperatures above 60° F. Below this temperature, water usage was scattered with little trend.

Options for Conserving and Recycling Water

Possible environmental and economic benefits could be obtained by reducing the amount of water used at the feedyard, or recycling water that is currently lost to evaporation. Options for reducing the amount of water used at the feedyard include: 1) installing more efficient water troughs, and 2) making improvements to existing systems to reduce leakage. Options for recycling or otherwise using the overflow water include: 3) recycling the water back into the drinking water system, 4) using the water for irrigation purposes, 5) using the water for dust and temperature control in sprinkled pens, or 6) using the water in the feedmill.

Reduction of Water Usage By Installing More Efficient Water Troughs. Insulated water troughs now on the market may conserve water compared to non-insulated troughs. It is unknown whether benefits in water savings would offset costs for installing new water troughs in existing feedyards. The amount of water saved would depend on the condition of the existing troughs. New feedlots should be designed with water conservation in mind.

Improvements to Prevent Leakage. By making improvements to water trough plumbing, the amount of leakage entering the overflow system could be reduced. These improvements may be easily performed in some instances, however, in older water troughs improvements could be major. The improvements would result in less water used during the summer months. Based on results at this feedyard, about 0.81 gal/head/day could be conserved during summer weather conditions assuming all leakage to the overflow system could be prevented. Over a period of seven months, this would equal 8.5 million gallons of water conserved.

Recycling Overflow Water Back Into the Drinking Water System. The overflow water could be collected and pumped back into the drinking water distribution system. For feedyards with an overflow collection system that routes to one outlet, this would be a simple system to install. Based on results at this feedyard, about 4.33 gal/head/day were used for freeze protection during the five freezing (winter) months, which was 32.5 million gallons of water. Leakage during the seven non-freezing (summer) months accounted for 8.5 million gallons of water, and cleaning of tanks accounted for 1.7 million gallons of water per year. This totals 42.7 million gallons of water per year that could be recycled.

Irrigation of Crops. Using the overflow water for irrigation would require building a storage structure for temporary storage of the water before applying to the land. The overflow water could be allowed to flow into the stormwater runoff control structure which most feedyards have already constructed, then the combined overflow water and stormwater runoff could be used for irrigation. As the overflow water is typically only a very small percentage of the total runoff, the water quality of the runoff would be the deciding factor for land application. As shown in Table 5, water samples from the runoff storage structure had elevated salt concentrations and electrical conductivities. Salinity is one of the limiting factors for land application of effluent (Sweeten, 1990).

Dust and Temperature Control in Sprinkled Pens. Some feedyards in the area have installed sprinklers throughout the pens. The sprinklers serve two purposes, they reduce dust emissions from the feedyard surface, and they cool the cattle during hot periods. Based on the water quality analyses of the overflow water, the overflow water could be used for sprinkling pens. Use of the overflow would require construction of a storage structure. During winter months and periods when no sprinkler water was used, other uses for the overflow water would be needed.

Recycling for Use in the Feedmill. The overflow water could be used in the feedmill for steam flaking of grain provided that the overflow water met the water quality requirements for the mill. Some feedmills in the area currently treat their water prior to using it for feed processing. Use in the feedmill would be site specific and dependent on the feedyard water supply and overflow water quality. The overflow water could probably be used with minor treatment, however, it is improbable that the feedlot runoff could be used without major treatment. For this reason, a separate storage structure would be needed for the overflow water.

Economic Consideration. At feedyards that rely on groundwater for their water source, groundwater pumping costs (electricity only) in the Texas High Plains range from about $0.11 to $0.19 per thousand gallons. Total operational costs vary depending on pumping depth, pump efficiency, and electricity costs. The cost to operate booster pumps to move water and pressurize the delivery system adds another $0.05 to $0.16 per thousand, for a total water cost of between $0.16 and $0.35 per thousand.

If all of the overflow water including leakage and tank cleaning were recycled at this feedyard, then 42.7 million gallons of water would be saved per year. Using the operating costs developed for groundwater sources, this equates to between $6,832 and $14,945 per year, or $569 to $1,245 per month. The actual cost of overflow water at this feedyard, including pumping, is about $0.35 per thousand, or $1,245 per month.

A water treatment system was designed to recycle the overflow water back into the drinking water system. The treatment system consisted of an automatic backflush filter, an automated chlorinator, and all pumps, piping, and controls to pump the treated water back into the drinking water supply system. Total cost for the treatment system was estimated to be $39,000. Monthly operating costs (electricity and chlorine) were estimated to be $538, assuming water would be treated to 5 ppm initial chlorine with $0.065/kwh for electricity.

The payback period on the capital investment was calculated for annual interest rates of 4, 6, 8, and 10% (Table 3). The payback period on the capital investment ranged from 61 months at 4% interest to 74 months at 10% interest. A net savings of $707 per month would be realized after payback of the capital investment.

Table 3. Payback period on capital investment at various annual interest rates.

	Annual Interest Rate			
	4%	6%	8%	10%
Payback Period (months)	61	65	69	74

Monthly water savings would have to be at least $538 to recover monthly operating costs. A recycle water system may not be economical at small feedyards, feedyards with inexpensive shallow groundwater sources, or feedyards with well designed and efficient water delivery systems.

CONCLUSIONS

Several options were identified for conserving water at feedyards. However, most of these options would cost quite a bit to implement. At present, market conditions for the fed cattle market are extremely poor. Thus, it may be difficult for a feedyard to justify spending money on a water recycle system that takes nearly six years before seeing any return on the investment. Other options such as alternative water treatment systems, including the no-treatment option, should be evaluated in a research setting.

Another major consideration that may cause feedyard operators to be hesitant in returning the overflow water back into the cattle drinking water system relates to animal health issues. For example, pathogens from a sick calf would only expose one water trough using the current distribution system, but could possibly expose the entire yard if an overflow distribution system were in place. Because the viability of these pathogens is unknown, research to determine risks from recycling drinking water is warranted. Treatment systems such as filtering and chlorination could probably reduce pathogen risks, however, costs for treatment systems might prohibit their installation at feedyards.

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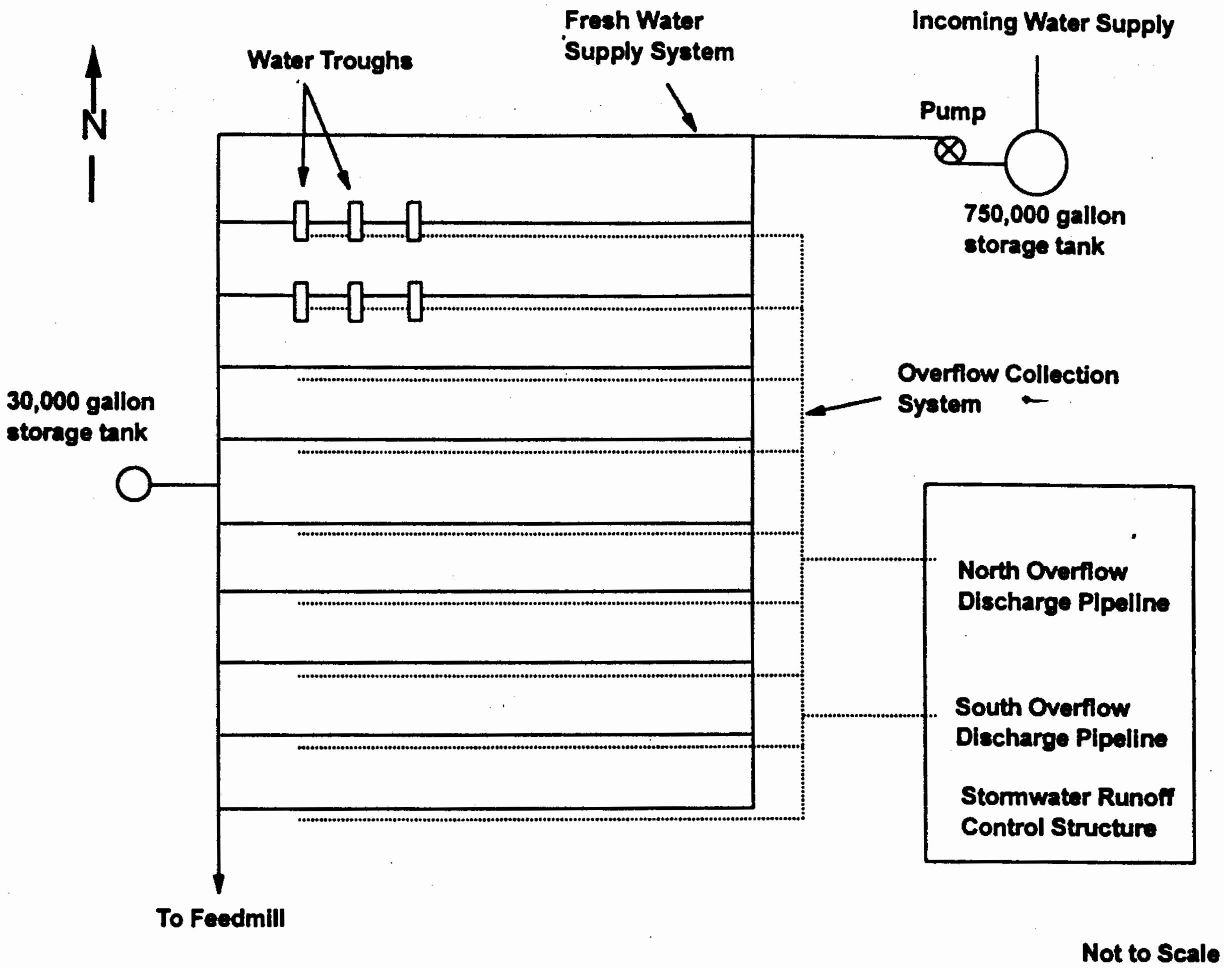

Figure 1. Layout of the feedyard water supply and overflow collection systems

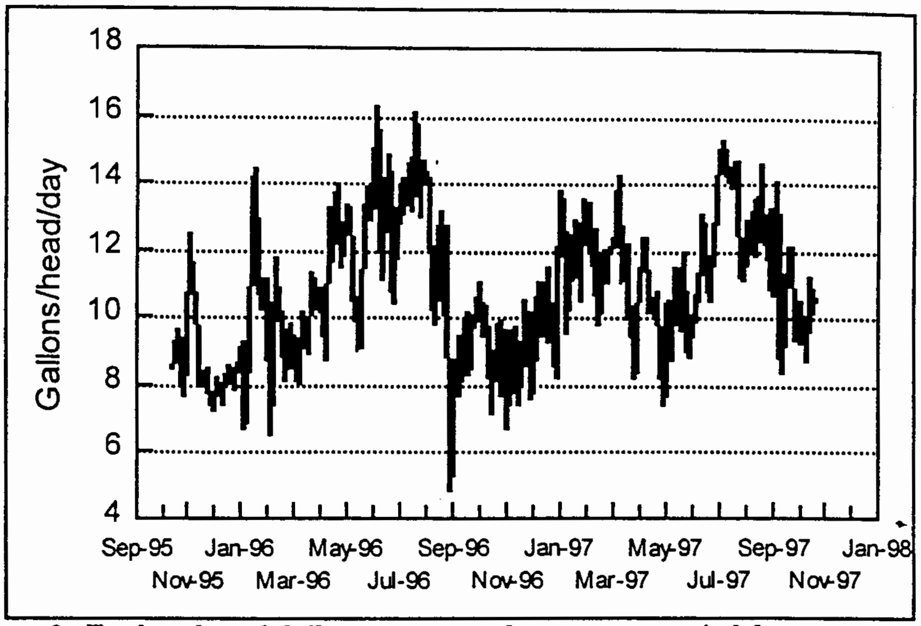

Figure 2. Feedyard total daily water usage for two year period from November, 1995 to October, 1997. Values plotted are 5-day moving averages to smooth variability caused by storage volume effects.

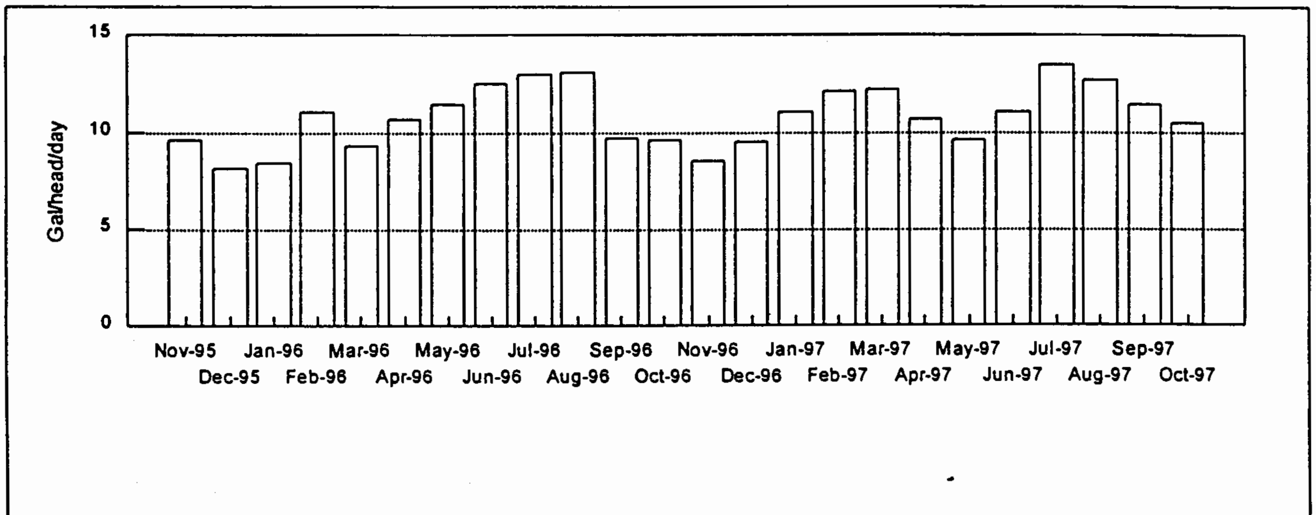

Figure 3. Average daily feedyard water usage by month. Totals include all water used at the feedyard (drinking, overflow, feedmill).

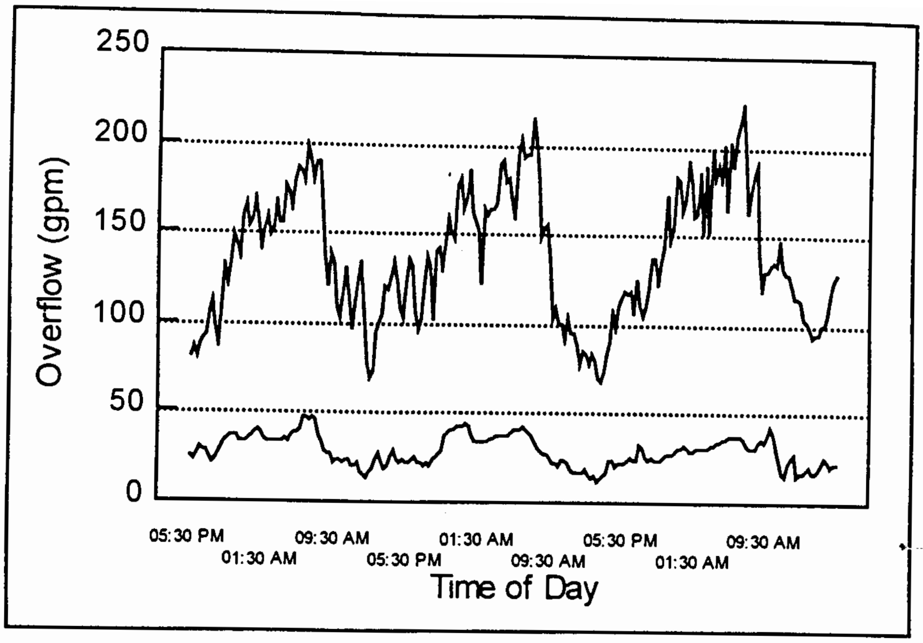

Figure 4. Water trough overflow with floats adjusted for winter conditions (top line) and summer conditions (bottom line).

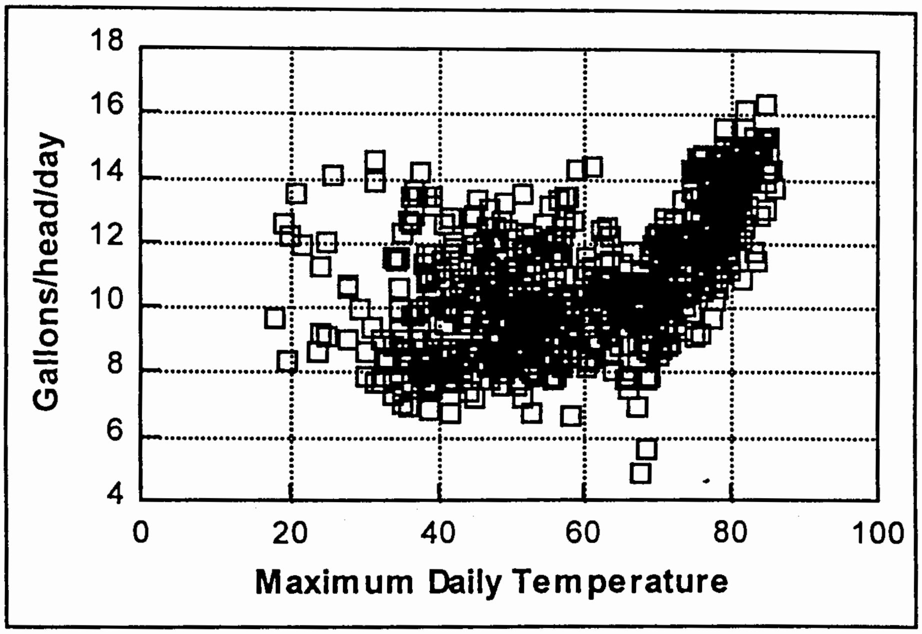

Figure 5. Graph showing relationship between maximum daily temperature and water usage for two years of data.