# Water Supply Case Study

## *Summary*

This case study examines a US pig breeder farm with a site water meter. The data is analysed and presented in different ways which suggest a progressive deterioration in the water supply capacity.
The article goes on to suggest that analysis geared to discovering progressive loss of equipment performance would be worthwhile.

## *Introduction*

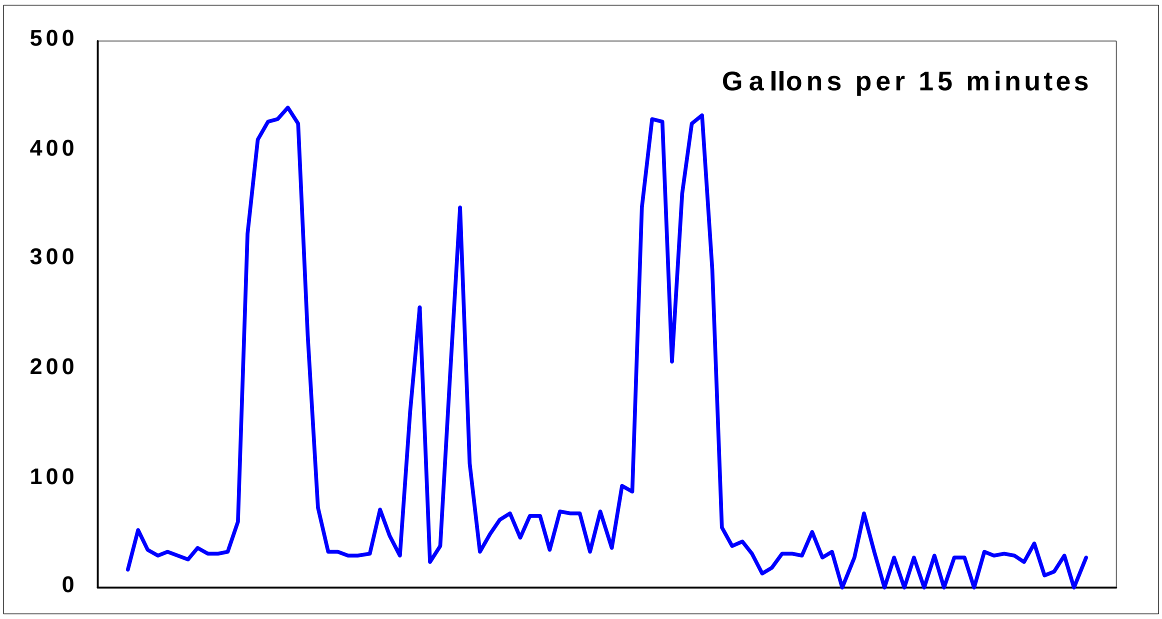
Water measurement is becoming increasingly common, but relatively few breeder sites have meters with monitoring.
The site studied is a 2500 sow US breeder site with 16 farrowing rooms and 2 BG barns. Farrowing rooms have meters, and there is also a general site supply meter. Unfortunately, there are no meters in the BG barns. Water consumption here would be expected to dominate the total use and assumptions have had to be made as regards water use in these.

## *General Description*

The site has two wells, each with a bore hole pump rated 25 to 30 gpm (gallons per minute) when drilled. These supply a 25,000 gallon holding tank. This has two 1 hp submersible pumps (each rated 20 gpm) operating in two stages (according to pressure) which supply a pressure vessel providing a pressurised supply for the farm.
Site metering is in the supply between these pumps and the pressure vessel.

## *Total daily water pattern*

Daily water use varies somewhat, but is typified by the following general curve :



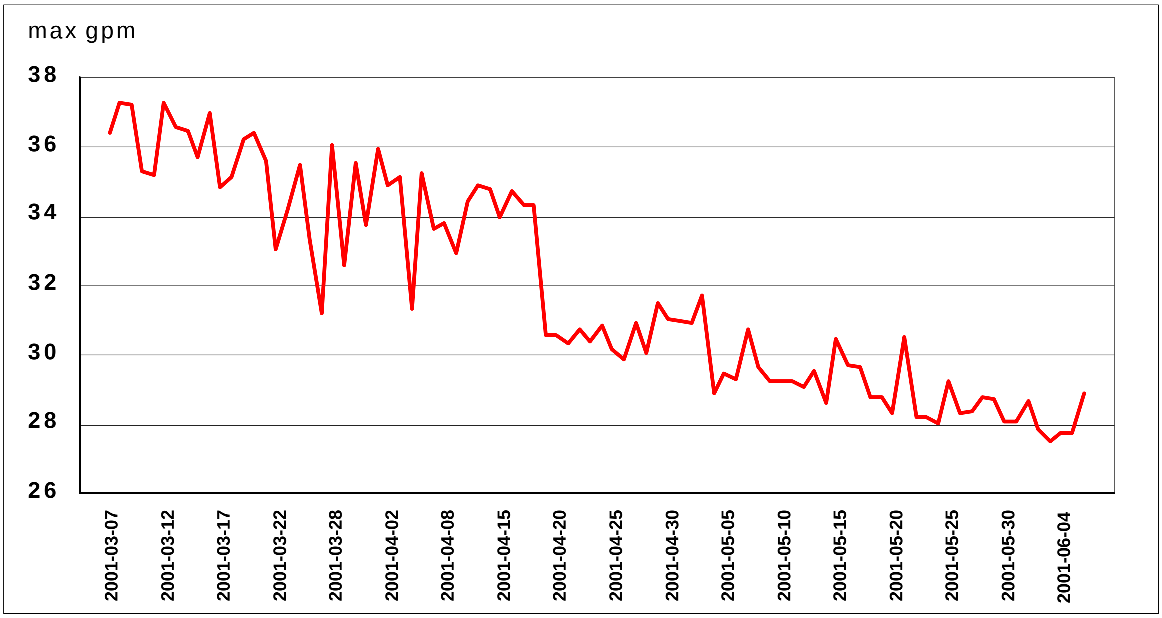

Figures are given per 15 minutes, being the logging interval of the monitoring system.

As we can see, total water use is dominated by one large peak in the morning, and two in the evening. From time to time, the two peaks in the evening may be more or less separated. It's presumed these are due to refilling of holding tanks in the BG barns. In the morning, both barns are fed at the same time, but in the evening they have been at similar but not always the same time.

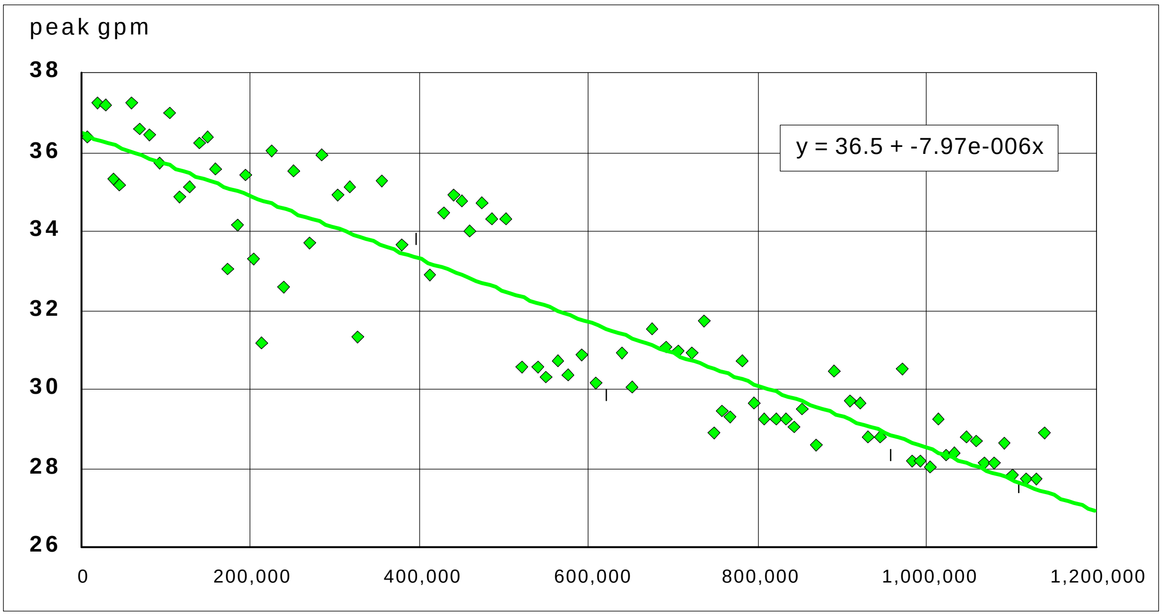
These peaks amount to around 2/3rd of typical total daily site consumption - around 1.5 to 2 gallons per sow in the BG barns.
The striking feature is that whether the peaks are coincident or not, the peak value is always the same. The variation in volume results in a change in width not height - i.e. the peak value varies in duration.

This indicates that water delivery is limited by supply rather than demand.

It is a reasonable assumption that the rate of water delivery is limited at the supply by the pumping capacity of the two pressurising pump. Therefore, that the peak value measured on any particular day represents the limit of their capacity.
The peak daily delivery rate has therefore been extracted from the data and converted into gallons per minute :

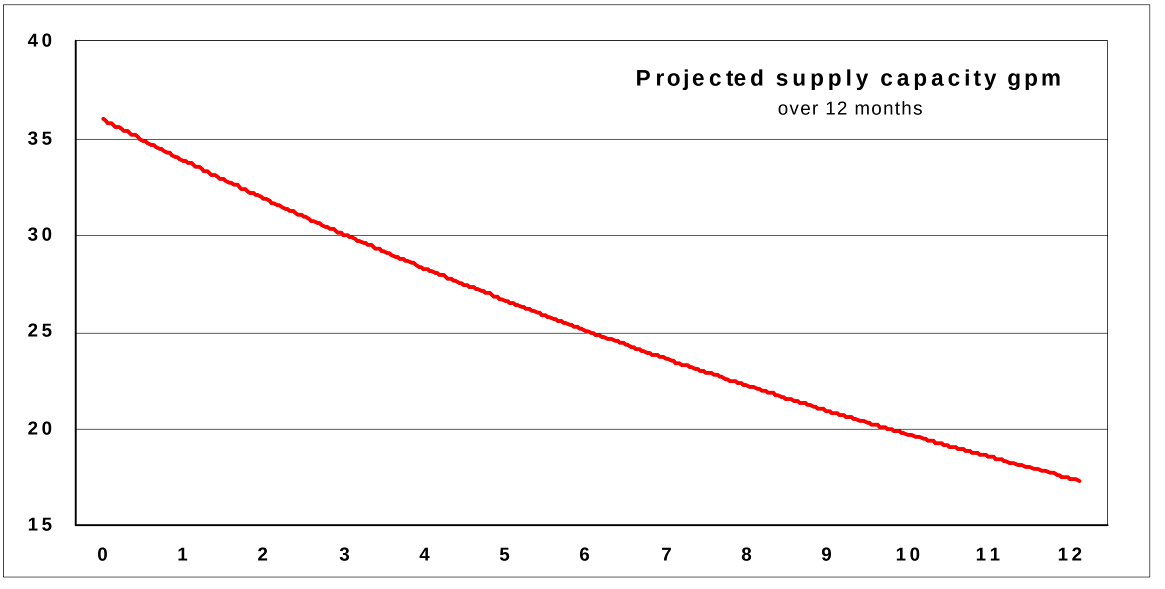



(Some figures adjusted/removed for evident data logging anomalies.)
This shows that the pumping capacity is falling over a period of time. Carrying out a regression analysis of peak capacity against total volume delivered shows the following relationship :

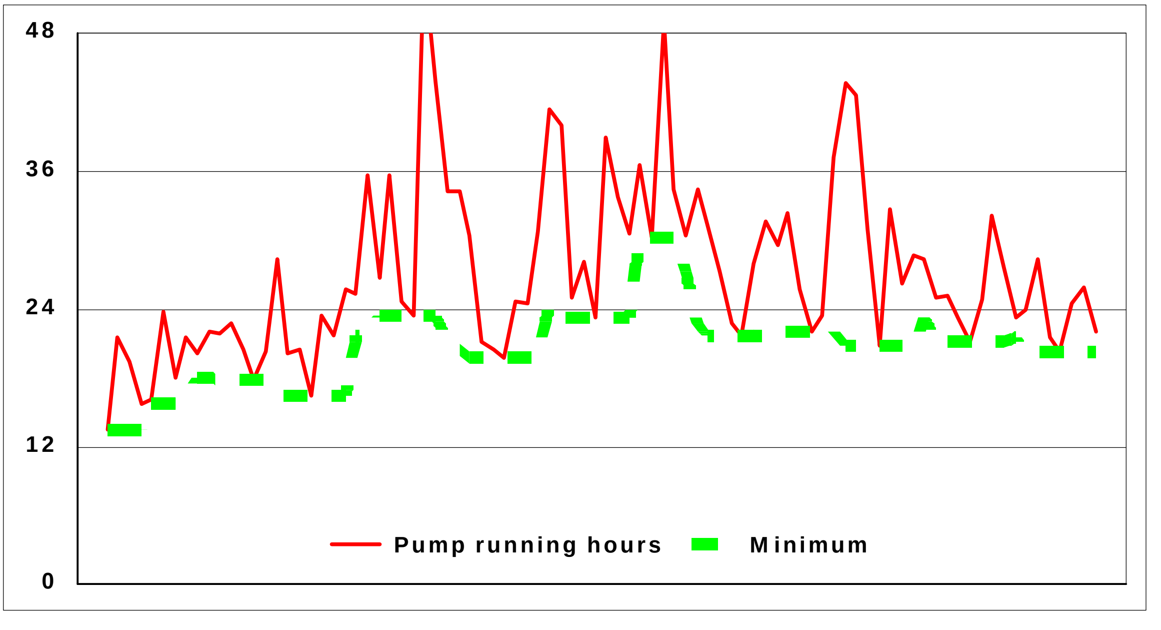


That is, the system is losing pumping capacity at the rate of 7.97 gpm per million gallons delivered i.e. 21.8% per million gallons. This averages 0.11 gpm per day. During the period measured, capacity seems to have fallen by about 23% over the period measured (from 36.5 to 28 gpm(On this basis, supply would drop to zero within a year.

Closer review of the data suggest that the relationship is actually of two parts. Up to about day 40, then from day 40 on, with a step change in the middle. (Around 20th April 2001.) These two parts have a slightly slower reduction in capacity - 0.072 and 0.064 gallons per day respectively. These figures amount to approximately 0.2% per day.
Based on this relationship, the following peak delivery capacity is predicted :



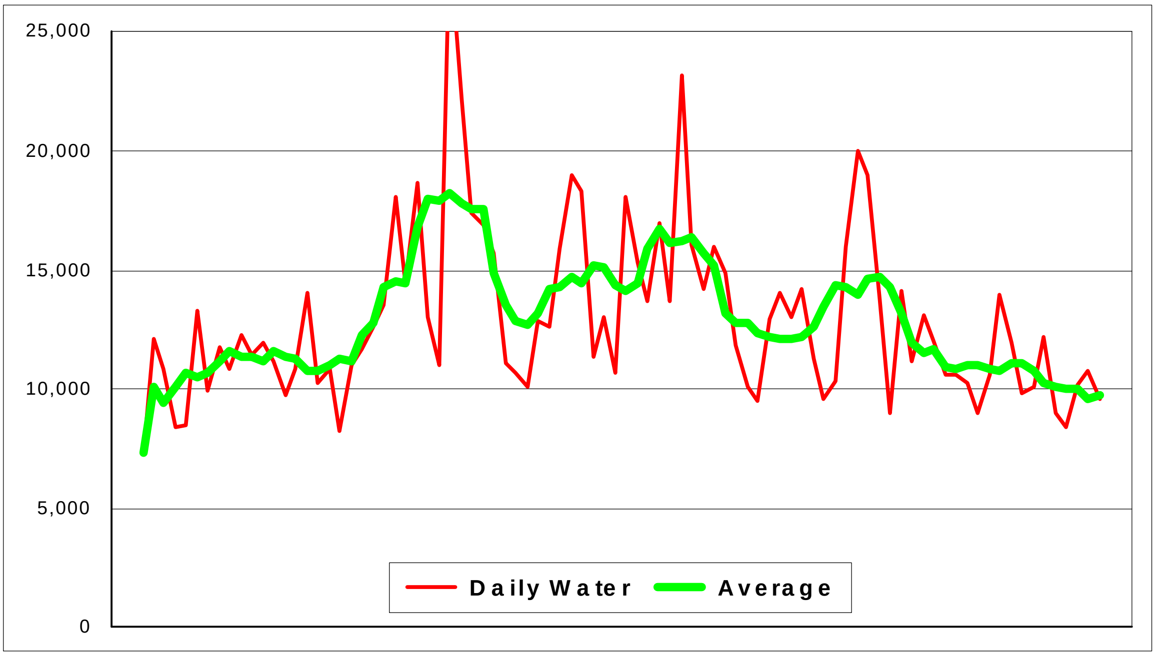

The effect of reduced peak pumping capacity would be that pumps would need to run for more hours per day.




This charts shows the number of hours the pumps would need to run to supply the total volume measured, based on the pumping rate estimated by the peak rate measured. Since there are two pumps, the scale goes up to 48 (i.e. two pumps each running 24 hours). Since the actual demand varies from day to day, the Minimum line shows the least number of hours calculated over a period of about a week. This suggests that the pumps progressively need to run longer to supply the daily volume required.

(Please note, data logging anomalies on a couple of occasions explain the apparent values greater than 48 hours in one day.)

The exact cause of the apparent progressive reduction is not clear.
A consideration might be that the meter itself is not registering correctly. (The meter failed at the end of the logging period.) The following chart shows the daily volume measured, with an averaged line for extra clarity :




It's noted here that the daily volume is similar at the end to the beginning. Whilst a fault in the meter cannot be discounted, it seems unlikely. Looking at similar total daily volumes, it seems that early on it takes around 17 pumping hours for 12,000 gallons, whilst at the end it is around 21 hours.

Two general reasons suggest themselves :
- increased flow resistance
- loss of pump performance

Increased flow resistance would be due to increased resistance in pipes (e.g. pipes narrowing because of scale build up) or progressive blocking of filters.
(Note : If resistance is the cause, then loss of capacity would not be linear in the long term as indicated, as flow resistance is generally related to water velocity squared.)
Loss of pump performance would be due to factors such as wear in seals and bearings which would worsen the pump's pressure/delivery characteristic.

The step change around day 40 (29$^{th}$ April) in the above data is of concern, since the system appears to have lost around 4% of capacity on a single day. Such problems could occur at any time in the future.

## *Impact*

If these projections were correct, then one would expect progressively increasing impact on production due to increasing differences between different points in the installation.
At present, the maximum typical daily demand on the site is around 18,000 gallons (including pressure washing). This total capacity could still be delivered even if supply capacity fell to 12.5 gpm. However, it would be expected that significant consequences to functional performance would be experienced before this point was reached.

## *Review & General Points*

During the period of logging, this site appears to have lost around 20-25% of it's water delivery capacity. Whether this is true or not, the analysis suggests that further investigation on this site is justified.

Fault detection systems in pig production, such as they are, tend to focus - perhaps over much - on acute equipment failure (such as ventilation failure) rather than general operating performance parameters.

In this case, there appears to be a loss of performance without there being a "fault" or acute failure. (Or at least, there have been specific problems such as burst pipes, but these are a separate issue.) Sooner or later, unless corrected, this would be expected to have an impact on production, and possibly lead to acute failure.

Many of the systems installed on a typical farm could lose performance in this way - ventilation, feeding systems and so on. But, since they have varying output and performance in response to changing demands anyway, effects may not be immediately apparent. Effects may differ markedly according to the type of system and the type of deterioration. For example, augers may become increasingly erratic due to wear in control components. Such marginal changes in performance may not be obvious but may have symptoms, if only we could read them.

Taking a broader view, farms are often seen to have a gradually changing pattern of use. Some are due to response to changing climatic and similar external effects, some are due to a progressive optimisation by the farm itself. Some are undoubtedly due to things gradually going out of kilter - whether by the equipment, or because bad habits become gradually entrenched.

There seems to be a good case for data analysis geared to detecting, examining and investigating such changes. By its very nature, such analysis may not have a predicted outcome nor a clear message and as in this case, may involve analysis of data in unusual ways.

Coming back to this particular case, several methods might be used to track the changes in system throughput. At its simplest, an additional display in Barn Report indicating the maximum throughput in any 15 minute interval on each day would be a simple addition.

In more general cases, measurement of pump motor run time (as for auger run time) may be useful. Ideally it would be compared to metered throughput to indicate changes in pumping efficiency. Further software development could mean that the maximum throughput could be measured directly by measuring flow rate using a different type of meter.