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Feedyard Dust Control in an Epic Panhandle Drought, 2010-2011

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Summary

Feedyard surfaces in the Texas Panhandle cannot possibly get any drier than they are as of July 1, 2011. The information contained in this bulletin is intended to serve as a summary of dust mitigation practices that have been evaluated by scientists and engineers in the Texas Panhandle over the past 20 years. Feedyard managers will need to evaluate the feasibility of practices based on the feedyard's location and available resources.

- As the springtime winds give way to lower wind speeds of summertime, cattle feedyards in the Texas Panhandle will be in a "red flag" condition for fugitive dust, especially from 5:00 pm to midnight.
- If uncompacted manure depths on the feedyard surface are low (0.5" or less), direct water application via sprinkler or water truck may still be effective at controlling dust, but current evaporative demand is likely to exceed 0.25" per day, well above the industry's average daily application rate. Many feedyards' sprinkler systems are not designed to apply that much water across the entire feedyard, and midday wind speeds exceeding 15mph make it unwise to run sprinklers during the heat of the day anyway.
- If uncompacted manure depths on the feedyard surface exceed 1", supplemental water and the energy and labor required to apply it are both likely to be wasted.
- The #1 dust-control priority for feedyards - **this year and every year** - is strategically, aggressively, and carefully harvesting the uncompacted manure from corral surfaces.
    - If possible, begin along the N, NE, and E edges of the feedyard and work toward the S, SW, and W. This approach begins with those pens likely to affect downwind neighbors the most.
    - Pens with steers/heifers nearing slaughter weight are accumulating uncompacted manure faster than any other sector; put these pens at the top of the priority list.
    - When practical, focus manure-harvesting activities during midday (~9:00 am to 3:00 pm) when solar radiation and higher winds create maximum turbulence in the atmosphere and neighbors tend to be indoors or at work.
    - Box blades, when properly adjusted and attentively operated, produce the best results: a hard, smooth, and even pen surface. However, they have limited capacity and must be emptied frequently to avoid "spillage" of dry manure out the front corners of the box.
    - Box blades can often be run successfully in populated pens, but manure collected should be either
        (a) removed in a timely way by front-end loader to a manure truck, dump trailer, or other transport vehicle, or
        (b) compacted in place (i. e., in a mound at the back of the pen) with sufficient water to reach 25-30% moisture for maximum compaction.
- A well-managed composting program or manure-storage area managed in compliance with environmental regulations and permit provisions will allow harvested manure to be completely removed from the pens even when farmer demand for manure is low.
- The maximum amount of water that would need to be added to dry, collectable manure to reach the 30% threshold for good compaction-in-place in an in-pen mound is about 650 gallons per acre of pen surface per inch of collectable manure depth. Thus:

____________	X	____________	X	650	=	____________
Acres of pen surface		Avg. manure depth (in)				Gallons H_2O

If the dimensions of an individual pen are known, the maximum water needed for a single pen would be:

________	X	________	X	____________	X	0.015	=	________
Pen width (ft)		Pen depth (ft)		Avg. manure depth (in)				Gallons H_2O

The Drought of 2010-2011

Nobody who has lived in the Texas Panhandle - the “Cattle Feeding Capital of the World” - for very long will be surprised to hear that we are in the midst of an epic drought. However we look at it, the picture is the same: La Niña, the cyclical cooling in the western Pacific Ocean that strongly influences the Southwest’s climate, has given us a moisture deficit from which it may take years of above-average precipitation to recover. The chart below tells the rainfall story.

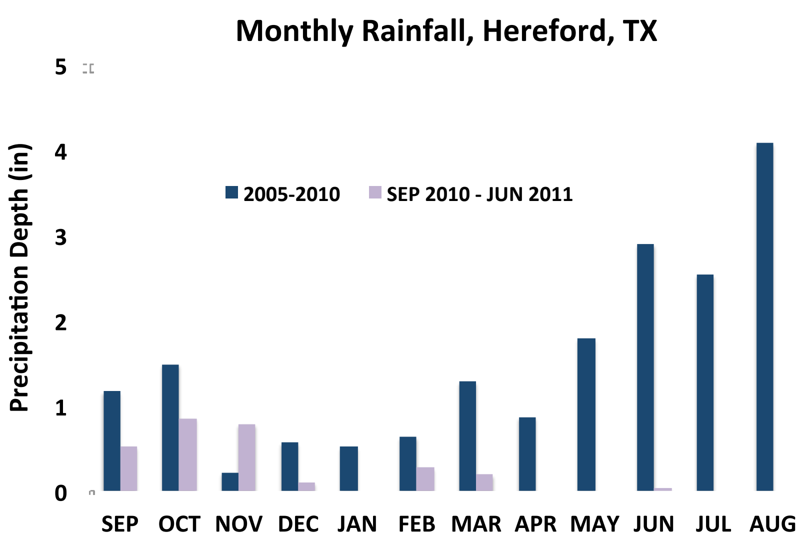

Figure 1. Monthly rainfall from September 2010 through June 15, 2011, compared to the seven-year (2005-2010) averages. (Data courtesy of the Texas Tech Mesonet, site “Hereford 2NW.”)

Hereford’s average annual precipitation from 2005-2010 was in line with longer-term historical averages, about 18 inches per year; six months into 2011, Hereford has received about a half an inch. For the months of September through June, the average total rainfall from 2005-2010 has been about 11.4 inches; from September 2010 until now, Hereford has received less than three inches.

Rainfall data from between Happy, TX, and Palo Duro Canyon tell much the same story. Over the past three years, considering the September to August “precipitation year” in which our current drought has appeared, the 2007-2008 precipitation year was by far the driest; but as Figure 2 shows, our cumulative rainfall for the 2010-2011 precipitation year has now crossed below even 2007-2008’s minimum, with no relief in the near-term forecast.

Maximum temperatures during the late spring and early summer of 2011 have also been extreme, with mid-June daily maxima exceeding 100°F. It has not been uncommon for afternoon relative humidities to reach 4-6%. Consequently, the calm-air drying potential - measured as the vapor pressure deficit, or VPD - has been significantly higher during the first six months of 2011 than during the same periods in 2008-2010 (Figure 3). Daily average wind speeds have been at least as high during 2011 as in previous years (Figure 4), so the actual drying potential during 2011, which results from the interaction of wind-speed and VPD effects, has been considerably higher in 2011.

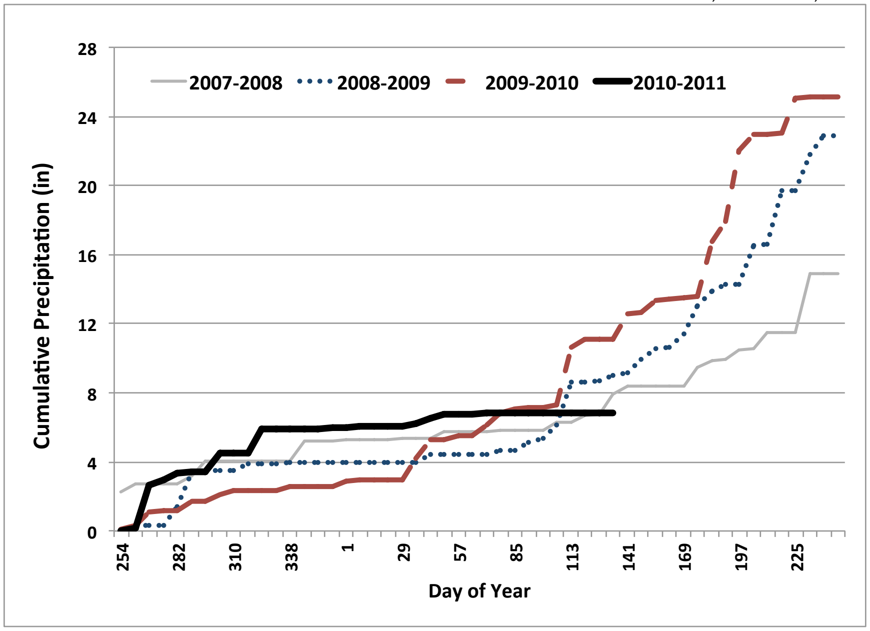

Figure 2. Cumulative rainfall from September (DOY 254) through August for the south-central Texas Panhandle. DOY=1 is January 1st. (Data courtesy of the National Atmospheric Deposition Program, site TX43 "Canonceta.")

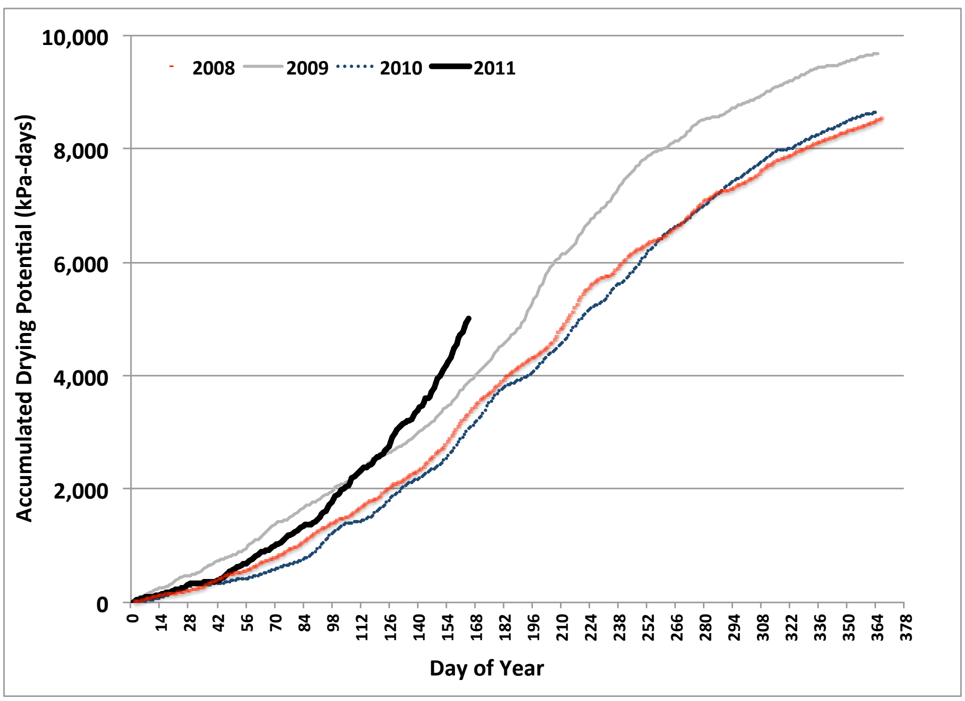

Figure 3. Cumulative calm-air drying potential (aka, "vapor pressure deficit"; daytime only) for the south-central Texas Panhandle for calendar years 2008-2011. (Data courtesy of the Clean Air Status and Trends Network, site PAL190 "Canonceta.")

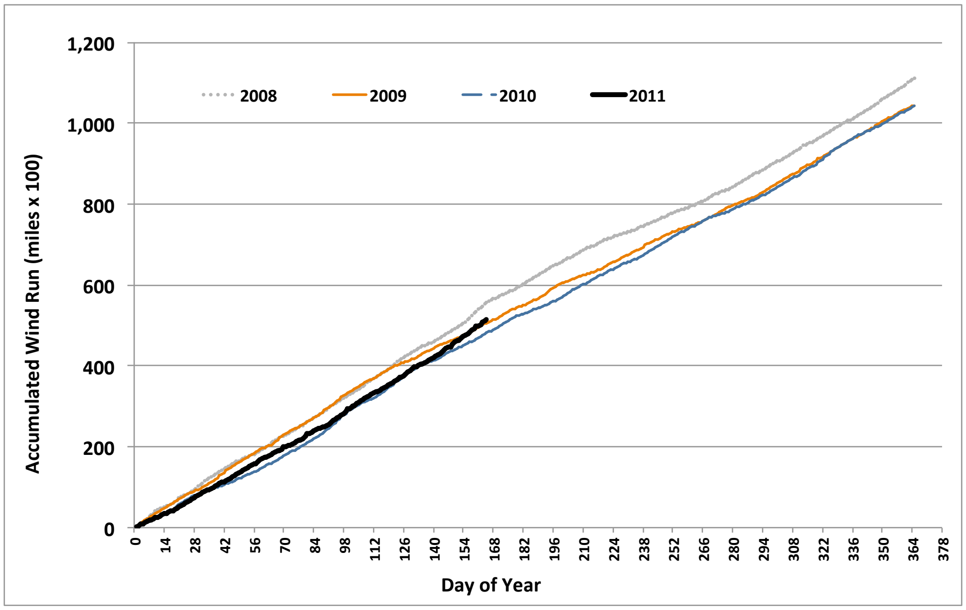

Figure 4. Cumulative wind run for the south-central Texas Panhandle for calendar years 2008-2011, showing that Panhandle winds during 2011 (the heavy, black line) have been at least as strong and persistent as usual. Cumulative wind run is the distance a parcel of air will have been carried along by the wind over the elapsed time, in this case since January 1 of each year. The slope of these lines is the annual average wind speed, ~5.4 meters per second (~12 mph). (Data courtesy of the Clean Air Status and Trends Network, site PAL190 "Canonceta.")

Implications for Feedyard Dust

With the extended drought conditions described above, we can be sure that cattle feedyards and their neighbors are in *nearly* worst-case conditions for dust. It would be just about impossible under current conditions for feedyard surfaces to get any drier or more dust-prone than they already are. At this point, the strong winds and bright sunshine that characterize the southern Panhandle are now actually helping us a little bit. It can - and will - get worse if wind speeds start to decrease for the remainder of the summer.

High winds and intense solar radiation tend to increase the atmosphere's turbulence near the ground, and that turbulence actually reduces ground-level dust concentrations by mixing the dusty air at the ground surface with the clearer air aloft. If conditions are already at their dustiest, in other words, high winds and sunshine actually reduce ground-level concentrations by dilution and dispersion.

But when wind speeds decrease, especially around sunset, watch out! Without enough direct sunlight to drive thermal convection - another form of turbulence, driven by the solar heating of the earth's surface - any dust emitted at ground level will tend to stay confined to a shallow layer of air near the ground, perhaps as little as 50 feet thick. These conditions, which atmospheric scientists label as "neutral" to "stable," permit almost no dilution or dispersion of ground-level dust. By itself, this stability effect would increase ground-level dust concentrations significantly. But it also coincides with (a) the driest manure of the day and (b) an increase in dust-generating animal activity, and the combined result is the well known "evening dust peak," which lasts until about midnight. This year, the evening peaks will likely be worse, and harder to manage, than usual.

What to Do About It?

There are four main areas of adaptive feedyard management that have an important bearing on dust emissions under these "exceptional" drought conditions:

- Uncompacted manure inventory
- Moisture
- Mulches
- Management of empty pens

Uncompacted Manure Inventory

The #1 priority for feedyard dust control is aggressive, careful, and strategic harvesting of the uncompacted manure on the pen surfaces. This material is stirred up by hoof action or resuspended by strong winds. Recent research using a benchtop hoof-action simulator showed that the dust-emission potential of a feedyard surface is roughly proportional to the depth of uncompacted manure. The rear hoof of a steer or heifer, dragging horizontally through this material, is probably responsible for most of the dust emissions that take place during the late afternoon and early evening hours as animal activity increases.

- Harvesting the dry, uncompacted material can be done in either occupied or empty pens using a small tractor and a box blade, or other equipment, to collect the manure and a front-end loader to load it into a truck or trailer in the working alley. It will be best if the manure can be completely removed from the pen (instead of stockpiled in the pen) so that animal activity does not redistribute it.
- If the manure cannot be removed from the pen, for either logistical or economic reasons, it needs to be moistened to about 25-30% and compacted in place in a mound at the back of the pen. The first page of this bulletin shows how to estimate the amount of water that will be needed to get the collected manure to the correct moisture range for compaction.
- Because our prevailing winds are from the S and SW, it's advisable to begin manure-harvesting operations on the N and NE portions of the feedyard unless there are good reasons to do otherwise. The downwind-most pens are most likely to contribute to nuisance conditions at nearby neighbors; the further upwind you go, the more of an effect dispersion and settling will have on neighbors' exposure to dust.
- Finished cattle near slaughter weight, whose rates of gain are low, are generating more manure solids per head than just about any other group of cattle on the feedyard. Focus manure-harvesting activities on pens with finished cattle, then move on to pens with young and very active cattle, which may not have had time to accumulate a deep layer of uncompacted manure.
- Set the implement's blade depth such that it does not cut very deeply into the compacted layer beneath. The main focus is the light, dry material. Avoid cutting into the mineral soil beneath the compacted manure layer.
- In pens where the uncompacted manure is deep, box blades will fill rapidly, and manure will quickly begin to spill out the front corners. Plan your box-blade path so that you can empty the box blade just as it fills. Otherwise, the pen surface will look deceptively hard and smooth, but the lines of spilled manure on either side of a box-blade path may be significant; and when you're pulling a box blade that's already full and spilling out the side, your time, labor, and diesel fuel are all being wasted.
- Concentrate manure-harvesting activities during midday (nominally 9:00 am to 3:00 pm), when the dust emitted by machinery operations will be dispersed by turbulence from direct sunshine and higher wind speeds.
- Feedyards that have the practical option of applying water to the pen surfaces are likely to find that aggressive manure harvesting will reduce the amount of water that they need to apply.

Pen Surface Moisture

- Our research has shown that a moisture content of 20% (wet basis) is a critical threshold for controlling dust, and 25% is a critical threshold for effective compaction.
- In a year like 2011, it will be nearly impossible to apply enough water to suppress dust if uncompacted manure depths average more than about 1". Harvest manure as aggressively and strategically as you can before trying to rely on water for extra dust control.
- Don't waste water on pens that have more than 1" of dry, uncompacted manure inventory (unless you have enough water to moisten the manure all the way through). Hoof action will penetrate the wetted crust and re-expose the dry material underneath.
- Daily evaporation rates from corral surfaces are likely to exceed 1/4" under the current weather pattern. Focus water applications where and when they will do the most good. If it's feasible to do so, focus water applications before each of the two critical times of day for neighbors' dust exposure: before (6:30-8:00 a.m.) and after (5:00-6:30) the work day - with emphasis on the early evening period.
- As with manure harvesting, prioritize on the basis of prevailing winds. If water is limited, focus water applications on the pens on the N, NE, and E sides of the feedyard, working back to the SW as good control is achieved.
- Run sprinkler sets longer to ensure good penetration of the water. If your sprinkler system is designed to put out 1/8" per day, instead of putting out 1/32" in each of four sprinkler cycles, put out the full 1/8" in one cycle, or break it into two 1/16" cycles, prioritizing by zones. If pen surfaces get muddy, reduce the amount of water applied or break the cycle durations in half.
- If water application is by truck, avoid wasting water on the area near the feed apron. Focus water on the back two-thirds of the pens.
- If you have electric cross-fences you can use to increase the stocking density, use them. Our research thus far has shown only a modest effect on dust concentrations, but unless you have observed that the cattle become more active at higher stocking densities (i. e., with buller or other aggressive behaviors), it can't hurt to let the cattle apply drinking water in a more concentrated way by reducing the pen area to which manure and urine are excreted.

Mulching the Pen Surface

Preliminary laboratory research indicates that some reductions in dust potential from the pen surface can be attained by applying mulches such as crop residues. Understandably, in years of drought such as 2011, the availability and feasibility of mulches will be minimal. Consideration should also be given to the additional volume of biomass that will added to the manure, which will eventually need to be collected and removed from the pen.

Mulches, especially crop residues like gin trash, hay, or straw, may reduce dust potential in two ways. First, they reduce evaporation and increase moisture retention in the manure below the mulch. Second, they dissipate or cushion the animals' hoof action, absorbing some of the mechanical energy that would otherwise lift dust particles into the air. Unfortunately, they also increase the volume and mass of manure that must be handled, harvested, stored, and land applied. But benchtop hoof-action simulators have shown that crop-residue mulches like hay and straw can be effective at reducing dust potential when applied to a pen surface at sufficient rates. During those benchtop simulations, waste-hay applications at about 7.5 pounds per head reduced dust potential by 45%, but we do not yet know how long that effect persists.

Management of Empty Pens

Although most of the nuisance conditions associated with feedyard dust are associated with the evening dust peak, strong winds at any time of day - but especially the hot, dry afternoon - may generate nuisance dust events via wind "scouring," the functional equivalent of wind erosion from open fields. The mechanisms are essentially the same: above some threshold wind speed, which will be lower for the lighter manure particles than for mineral soils, the scouring effect will increase with wind speed. As with cropland, then, the primary management practice is to increase the effective roughness of the surface, which will reduce the wind speed at that surface. Thus, cotton farmers will plant and then terminate wheat, or deep-plow their fields, to reduce wind speeds at the soil surface and thereby reduce soil erosion.

Analogously, when present at a sufficient stocking density, cattle themselves serve as a form of surface roughness, reducing the effective wind speed at the pen surface. Reducing wind-scoured dust emissions from empty feedyard pens implies the following management practices:

- Manure should be harvested from pen surfaces as soon as practicable after cattle are shipped, especially if the pen will not be repopulated for some period. Without cattle in the pen, the uncompacted manure layer is more vunerable to wind erosion without constant moisture input from urine and progressive compaction from cattle hooves.
- Prioritizing for both manure-harvesting and stocking decisions, give particular focus to empty pens that are more exposed to the wind: rows on the outer edge of the feedyard, pens on ends of rows, and pens whose feed alleys are parallel to prevailing winds. If feasible within the feedyard's management strategy, it may be best to keep these pens populated in preference to pens in the center of the feedyard if the yard is not full.

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