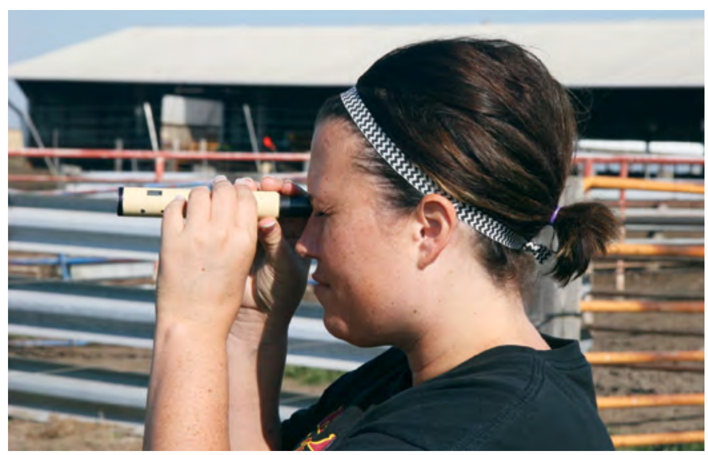
Clean Water Diversion for Open Feedlots

Open feedlots and any animal pens exposed to snow and rainfall will create manure-laden runoff. If runoff water from roofs, farmyards, driveways, or fields also enters the animal pens, additional manure-laden runoff is generated and additional manure may be scoured from the pens. Diverting clean (manure-free) water around the livestock pens can improve pen conditions and reduce the amount of pen runoff to be handled, stored, and distributed.

Runoff water that carries spilled feed products or leachate from silage may contain sufficient nutrients or pollutants to justify combining and managing it along with manure-laden runoff. Animal feeding operations with NPDES (National Pollutant Discharge Elimination System) permits may be required to contain this runoff (process wastewater).

Pen Location

Locating livestock pens at the top of the landscape can greatly reduce clean water diversion challenges. When the middle of a hillside must be used, avoid depressions where runoff water flows from uphill areas. Consider placing pen boundaries along contour lines or at angles that will make channeling clean water around the pens easier. A detailed survey of the site is helpful, but a simple hand level available from building suppliers may be sufficient to aid your decisions.



Roof Water

Roof water from adjacent buildings should be collected and diverted around animal pens. For smaller buildings, roof gutters and downspouts can be used to collect and divert the roof water. Common residential K-style gutters are sufficient for small buildings. Five-inch K gutter with a 2 x 3 downspout can handle roof water from about 600 square feet of roof. Six-inch K gutter

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with a 3 x 4 downspout can handle about 1,100 square feet of roof. For large roof areas, larger commercial gutters with multiple downspouts may be required. Downspouts that discharge into animal pens should be routed underground through solid pipe or non-perforated drainage tube to discharge points outside the pens and manure collection area. Downspouts will need protection from animal damage.

Roof water that falls outside the animal pens and manure collection area may be collected in concrete or earthen surface channels, or in gravel-filled trenches drained with perforated drainage tube. Estimate the roof water flow rate by multiplying the roof area times the rainfall intensity. In Iowa, consider using a 5-minute rainfall intensity of 7 inches per hour. Every 1,000 square feet of roof would generate 0.16 cubic feet per second (cfs), or 73 gallons per minute of flow (1 cfs = 449 gallons per minute). Consult drainage tube capacity tables to size a drainage line for moving roof water outside the manure collection area, or use Table 1 for estimating.

Table 1. Corrugated drainage tubing capacity (cubic feet per second)

Tube grade (percent)	Tube diameter (inch)					
	4	5	6	8	10	12
0.1	0.07	0.13	0.2	0.5	0.8	1.5
0.2	0.10	0.19	0.3	0.6	1.2	1.9
0.5	0.18	0.33	0.5	1.1	2.0	3.4
1.0	0.22	0.41	0.7	1.5	2.7	4.1
2.0	0.31	0.60	0.9	2.0	3.7	6.0
3.0	0.40	0.73	1.2	2.5	4.5	7.5

Surface Water

Runoff water from fields and yards that does not contain manure or feed should be diverted around animal pens and manure control areas. Accurate predictions of runoff flow rate rely on factors related to soil slope, infiltration rate, vegetative cover, previous rainfall, and other factors. NRCS (USDA Natural Resources Conservation Service) engineers can assist with accurate runoff predictions. For rough estimates that are usually conservative for midwestern soils and crops, the peak runoff flow rate (cfs) can be estimated by multiplying the drainage area (acres) by the rainfall intensity (inches per hour) for a one-hour storm. In Iowa, 2.5 inches per hour is a good estimate for a one-hour storm intensity. While this method gives a crude estimate, it is often sufficient for small field, pasture and yard watersheds, and non-critical structures and channels. Runoff rates from paved areas and very small drainage areas (less than one acre) may be considerably higher.

Flow rate (cfs) = Drainage Area (acres) x rainfall intensity (inches per hour). For example, flow from a 3-acre drainage area exposed to a 2.5 inch-per-hour rainfall event is estimated to be 7.5 cfs (3 x 2.5).

When possible, use surface channels to carry this “clean” water to avoid issues of capacity and plugging associated with pipelines. Diversion terraces or ditches can be installed upslope from animal pens to carry clean water across the ground slope (slightly down slope from a level contour line) and around the manure control area.

Surface channel capacity can be estimated using Manning’s equation:

$$Q = (1.486/n) \times S^{0.5} \times A \times R^{0.667}$$

Q = channel flow, cubic feet per second

n = channel surface roughness coefficient

S = channel slope, feet per foot of length

A = channel cross-sectional area, square feet

R = channel hydraulic radius = area divided by wetted perimeter, feet

Tables 2a to 2c give approximate capacity for vegetated trapezoidal earthen channels commonly used for waterways and diversion channels.

Table 2. Open channel capacity (cubic feet per second). Tables assume a roughness coefficient n=0.04, which is appropriate for bare earth or grass that is short or laid flat by flow. Trapezoidal channel cross section with flat bottom width as stated and side slopes of 3:1 are assumed. Flow numbers in italics indicate flow velocity above 5 feet per second, which may result in channel erosion without protective measures.

Table 2a. Channel grade of 0.5 percent

Flow depth (feet)	Channel bottom width (feet)				
	1	2	4	8	12
0.5	1.47	2.23	3.81	7.06	10.3
	(low velocity may cause settling at this depth)				
1.0	7.02	9.35	14.2	24.2	34.5
1.5	18.5	23.0	32.2	51.6	71.5

Table 2b. Channel grade of 1.0 percent

Flow depth (feet)	Channel bottom width (feet)				
	1	2	4	8	12
0.5	2.08	3.16	5.40	9.98	14.6
1.0	9.93	13.2	20.0	34.3	48.8
1.5	26.1	32.5	45.6	73.0	101

Table 2c. Channel grade of 2.0 percent

Flow depth (feet)	Channel bottom width (feet)				
	1	2	4	8	12
0.5	2.94	4.47	7.63	14.1	20.7
1.0	14.0	18.7	28.4	48.5	69.0
1.5	36.9	45.9	*64.5*	*103*	*143*

Surface channels should be graded along their length to keep flow velocity in the appropriate range. Flow velocity less than 1.5 feet per second will allow solids settling to occur in the channel. Flow velocity greater than 5 feet per second may cause erosion in earthen channels unless they are adequately protected.

Earthen channels with lengthwise grade around one percent generally maintain flow velocity between 1.5 and 5 feet per second. When flow velocity must be greater than 5 feet per second, consider using a channel made of concrete or lined with some other protective material.

When clean surface water needs to pass beneath pens or manure collection areas, surface intakes can direct flow into underground drainage lines. Use Table 1 or drainage tubing capacity tables to estimate flow capacities. Use non-perforated drain tubing when passing beneath livestock pens or manure storage or handling areas to avoid discharging manure nutrients and solids with the clean water.

Build intakes similar to terrace tile intakes or water and sediment control basin intakes. When space allows for a larger collection basin at the intake, the extra surge capacity of the basin will reduce the risk of overflow when the drain tube capacity cannot keep up with the peak runoff flow. Intake basins should be provided with an auxiliary spillway to safely release overflow when the drain tube capacity is surpassed.

When surface water drainage needs to cross a driveway, use either a low-water crossing or a culvert to carry the flow. Low-water crossings can be surfaced with concrete, large rock, or recycled concrete slats. Culverts provide the advantage of keeping the driveway surface dry, but can be prone to plugging with debris or sediment. Make sure the channel leading away from a culvert has sufficient capacity to avoid sediment collection backing up into the culvert. Culvert capacity can be determined from culvert tables or figures, or can be estimated with figures from Table 3.

Table 3. Culvert capacity (cubic feet per second)

Water depth at inlet measured from bottom of culvert	Culvert diameter (inches)					
	12	15	18	24	30	36
½ culvert diameter	0.7	1.2	1.8	3.9	6.5	10
1 culvert diameter	2.1	3.5	6.0	12	20	32
2 culvert diameters	4.2	7.0	11	22	40	64

Table assumes culvert length no more than 50 times culvert diameter, and free outlet

Outlet Location

Clean water diversion channels and tubes can carry significant flows. Outlet locations may require erosion protection to prevent scour holes and gullies from forming. Avoid discharging diversion flows onto sloped ground that is not designed to carry concentrated flows. Road ditches and grassed waterways may be suitable outlet locations if they are sized to accommodate the additional flow.

Maintenance

Gutters, downspouts, drainage tubes, and open channels for clean water diversion all require routine maintenance. Protect these flow pathways from animal damage and check them frequently for damage, erosion, or siltation. Silt removal may be required in areas with low flow velocity. Consider increasing channel grade or flow depth if an increase in flow velocity is desired to reduce siltation. Where erosion is a problem, either armor the channel or decrease flow velocity by decreasing grade, increasing width, or increasing the roughness of the channel.

Vegetation can be difficult to establish and maintain when a constant flow of water is present. If possible, temporarily divert flow around newly seeded areas until the seeding is established. If survival of the vegetation is a problem, consider a small underground drain to carry the constant small flows, keeping the vegetated open channel for larger intermittent flows. Seed with a grass mix that is suited for waterways.

Summary

Clean water diversion can improve animal pen conditions and reduce the amount of manure-laden runoff water to be managed. Attention to the location and layout of the feedlot can minimize the amount of clean water to be diverted. Thoughtful planning and maintenance will maximize the performance and longevity of the clean water diversion system. More detailed information about clean water diversion is available in chapter 4 of the *Livestock Waste Facilities Handbook*, MWPS-18, from Midwest Plan Service ***www.mwps.iastate.edu***.

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