# Irrigation Design Worksheet Version 3.0

*06/10/09*

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|---|---|---|
| **1. Design Flow and Septic Tanks** | | |
| *Determine daily wastewater usage (gallons per day (gpd))*<br>*Measured using water meter or estimated using 5 gallons per cow per day (# cows x 5 g/cow/day)* | | |
| 1 a. | Daily wastewater usage (# cows _____ x 5 gal/cow/day) ☐<br>Measured (_____ months) of water meter data ☐ | _____gpd |
| *Calculate minimum septic tank capacity. Select larger of:*<br>*3-day HRT (1a x 3)_____gallons ☐*<br>*Bulk tank volume_____gallons ☐*<br>*or minimum 1000 gallons ☐* | | |
| 1 b. | Minimum total septic tank capacity (maximum of values above) | _____gal |
| *Each septic tank chamber should allow for 2 or 3 days HRT (prefer 3-day). Calculate the minimum sizes of the chambers. This does not include pump tank volume. Make sure total volume of all septic tanks is at least the calculated minimum value (1b). Septic tank sizing is also a function of the manufacturer's actual tank size options. Typical sizes are multiples of 250 gallons.* | | |
| 1 c. | Chamber 1 (Daily water usage (1a) x 2 ☐ or 3 ☐ HRT) | _____gal |
| 1 d. | (optional) Chamber 2 (Daily water usage (1a) x 2 ☐ or 3 ☐ HRT) | _____gal |
| 1 e. | Total chamber volume (1c + 1d) | _____gal |
| *The pump tank volume is the minimum of 500 gallons ☐ or daily water usage ☐*<br>*Actual volume can be larger and is based on available sizes, often as a chamber in a dual chamber tank.* | | |
| 1 f. | Pump tank volume | _____gal |
| **2. Sizing of Irrigation Area** | | |
| *Determine the size of the irrigation area as a function of crop nutrient removal. Note that the irrigation area could be <u>larger</u> than the calculated minimum value. Calculations for determining nutrient removal are tricky and may take extra space. (NOTE: P removal not $P_2O_5$ removal as is listed in many fertilizer bulletins.)* | | |
| 2 a. | **Application Area 1**<br>Slope _____% *If slope is greater than 15% or slope is greater than 3% on tilled soils then us P for sizing.*<br>**Year 1= Corn ☐ Soybean ☐ Pasture ☐ Grassland ☐ _____ ☐)**<br>Yield ____(bu or tons/acre) x N removed ____ lbs/unit = _____lbs/acre<br>Yield ____(bu or tons/acre) x $P_2O_5$ removed ____ lbs/unit = _____lbs/acre<br><br>**Year 2= Corn ☐ Soybean ☐ pasture ☐ grassland ☐ _____ ☐)**<br>Yield ____(bu or tons/acre) x N removed ____ lbs/unit = _____lbs/acre<br>Yield ____(bu or tons/acre) x $P_2O_5$ removed ____ lbs/unit = _____lbs/acre<br><br>Ave. N removal for crop rotation ((crop 1 N + crop 2 N)/2) = _____lb/acre<br>Ave. P $P_2O_5$ removal for crop rotation ((crop 1 $P_2O_5$P + crop 2 $P_2O_5$)/2) = _____lb/acre<br><br>Required application area based on N (17,000 x # cows ÷ N removal) ☐<br>Required application area based on P (80,060 x # cows ÷ $P_2O_5$ removal) ☐ | _____$ft^2$ |

| | | |
|---|---|---|
| 2b. | **Application Area 2**<br>Slope _____% *If slope is greater than 15% or slope is greater than 3% on tilled soils then us P for sizing.*<br>**Year 1= Corn ☐ Soybean ☐ pasture ☐ grassland ☐ _____ ☐)**<br>Yield ____(bu or tons/acre) x N removed ____ lbs/unit = _____lbs/acre<br>Yield ____(bu or tons/acre) x $P_2O_5$ removed ____ lbs/unit = _____lbs/acre<br><br>**Year 2= Corn ☐ Soybean ☐ pasture ☐ grassland ☐ _____ ☐)**<br>Yield ____(bu or tons/acre) x N removed ____ lbs/unit = _____lbs/acre<br>Yield ____(bu or tons/acre) x $P_2O_5$ removed ____ lbs/unit = _____lbs/acre<br><br>Ave. N removal for crop rotation ((crop 1 N + crop 2 N)/2) = _____lb/acre<br>Ave. P $P_2O_5$ removal for crop rotation ((crop 1 $P_2O_5$P + crop 2 $P_2O_5$)/2) = _____lb/acre<br><br>Required application area based on N (17,000 x # cows ÷ N removal) ☐<br>Required application area based on P (80,060 x # cows ÷ $P_2O_5$ removal) ☐ | _____$ft^2$ |
| 2 c. | Number of months applied to Application Area 1 (Summer ☐ Winter ☐ ) | _____mo |
| 2 d. | Required Application Area 1 (2a × 2c ÷ 12) | _____$ft^2$ |
| 2 e. | Required Application Area 2 (2b × (12-2c) ÷ 12) | _____ $ft^2$ |
| **3. Number Zones and Number Irrigation Heads** | | |
| *Layout of application areas and zones is requires some trial and error since the number of zones also impacts the pump selection. The following calculations can be used as a guide in these calculations but additional calculations may be required or several iterations of these calculations. Sketch the proposed layout in Figure 1.* | | |
| **Application Area 1** | | |
| 3 a. | Irrigation head model _____ ; Spray diameter | _____ft |
| 3 b. | Full (100%) or fraction (%) spray pattern | _____% |
| *If irrigation head spray pattern does not overlap use 3c and 3d to determine number of heads. If you would like a more even application over your application area space your irrigation heads so there is spray overlap. To calculate the effective area for this layout, begin your calculations with 3e.* | | |
| 3 c. | Area covered per head (3.14 x 3a x 3a ÷ 4 x 3b ÷ 100) = | _____$ft^2$ |
| 3 d. | Divide required area by area per head to determine the number of heads required; always round up. (2d ÷ 3c) | _____ |
| 3 e. | *If spray pattern overlaps . . .*<br>Irrigation head spacing length (between 0.6 and 0.9 × 3a) | _____ft |
| 3 f. | Irrigation head spacing between rows (between 0.6 and 0.9 × 3a) | _____ft |
| 3 g. | Using trial and error and equations 1 or 2 (listed below) to determine required number of heads | _____ |
| 3 h. | Effective Application Area (EAA) (must be greater than 2d.) | _____$ft^2$ |
| 3 i. | Number of zones desired in Area 1 | _____ |
| 3 j. | Number of heads per zone (3d or 3g ÷ 3i) | _____ |
| 3 k. | Area per zone (*for no overlap* 3c x 3d ÷ 3i; *with overlap* use 3h ÷ 3i) | _____$ft^2$ |

| Application Area 2 | | |
|---|---|---|
| 3 l. | Irrigation head model _____ ; Spray diameter | _____ft |
| 3 m. | Full (100%) or fraction (%) spray pattern | _____% |
| *If irrigation head spray pattern does not overlap use 3n and 3o to determine number of heads. If you would like a more even application over your application area space your irrigation heads so there is spray overlap. To calculate the effective area for this layout, begin your calculations with 3p.* | | |
| 3 n. | Area covered per head (3.14 x 3l x 3l ÷ 4 x 3m ÷ 100) = | _____$ft^2$ |
| 3 o. | Divide required area by area per head to determine the number of heads required; always round up. (2e ÷ 3n) | _____ |
| 3 p. | *If spray pattern overlaps . . .* Irrigation head spacing length (between 0.6 and 0.9 × 3l) | _____ft |
| 3 q. | Irrigation head spacing between rows (between 0.6 and 0.9 × 3l) | _____ft |
| 3 r. | Using trial and error and equations 1 or 2 (listed below) to determine required number of heads | _____ |
| 3 s. | Effective Application Area (EAA) (must be greater than 2e) | _____$ft^2$ |
| 3 t. | Number of zones desired in Area 2 | _____ |
| 3 u. | Number of heads per zone (3o or 3r ÷ 3t) | _____ |
| 3 v. | Area per zone (*for no overlap* 3n x 3o ÷ 3t; *with overlap* use 3s ÷ 3t) | _____$ft^2$ |

## 4. Pump Requirements

*Pump selection is based on system flow and pressure requirements. The flow rate is a function of the number and type of heads and design pressures. Pressure requirements are a function of the elevation differences between the pump and the irrigation heads, the friction loss in the piping system, and the pressure requirement of the selected irrigation heads. The pressure and flow requirements will be different in each zone. The worst case scenario (highest pressure and flow) should be selected.*

| Area 1: Flow Rate | | |
|---|---|---|
| 4 a. | Flow rate of heads _____ gpm x Number of heads per zone_____ = | ____ gpm |
| **Area 1: Pressure Requirement** | | |
| 4 b. | ***Elevation Pressure Requirement***<br>Bottom of septic tank and highest ground elevation _____ ft + height of riser pipes _____ ft = **_____ ft**<br>***Pipe Friction Loss Requirement***<br>Diameter of supply line _____ in<br>Using Table 2 (below) determine friction loss in pipe<br>____ ft/100 ft x supply pipe length _____ ft ÷100 x 1.1 to 1.25 = **_____ ft**<br>***Irrigation Head Requirement***<br>Design pressure for irrigation heads _____ psi x 2.3 = **_____ ft**<br>Total system pressure requirement is sum of elevation, friction and head requirements | ____ ft $H_2O$ |

| | | |
|---|---|---|
| **Area 2: Flow Rate** | | |
| 4 a. | Flow rate of heads _____ gpm x Number of heads per zone _____ = | ____ gpm |
| **Area 2: Pressure Requirement** | | |
| 4 b. | ***Elevation Pressure Requirement***<br>Bottom of septic tank and highest ground elevation _____ ft + height of riser pipes _____ ft = **_____ ft**<br>***Pipe Friction Loss Requirement***<br>Diameter of supply line _____ in<br>Using Table 2 (below) determine friction loss in pipe ____ ft/100 ft x supply pipe length _____ ft ÷100 x 1.1 to 1.25 = **_____ft**<br>***Irrigation Head Requirement***<br>Design pressure for irrigation heads _____ psi x 2.3 = **_____ ft**<br>Total system pressure requirement is sum of elevation, friction and head requirements | ____ ft $H_2O$ |
| *Flow rate and pressure requirements for each zone are used to determine the size of pump. Typically this information is provided to a pump supplier and they make the proper pump selection.* | | |
| 4 e. | Pump make and model # _____ and pump HP _____ | |
| **5. Additional information** | | |
| *Sketch the location of the zone control valves in figure 1. These should be easily accessible throughout the year. Other design information might include specific float and timers for the pump.* | | |

Irrigation System Layout

**Table 1. Fertilizer recommendations for typical crops.**

| *Crop* | *Yield range* | *N removed* | *$P_2O_5$ removed* | **Elemental P removed* |
|---|---|---|---|---|
| ***Corn*** | *Corn 100-200 bu/acre* | *~0.8 lbs/bu* | *0.34 lbs/bu corn* | *0.15 lbs/bu* |
| | | *(80-160 lbs/acre)* | *(34-68 lbs/acre)* | *(15-30 lbs/acre)* |
| ***Soybeans*** | *Soybeans 30-50 bu/acre* | *3.5 lbs/bu* | *0.82 lbs/bu* | *0.36 lbs/bu* |
| | | *(105-175 lbs/acre)* | *(25-41 lbs/acre)* | *(11-18 lbs/acre)* |
| ***Corn-Soybean Rotation (2-yr average)*** | | *92.5-167 lbs/acre/yr* | *29-54.5 lbs/acre* | *13-48 lbs/acre* |
| ***Pasture or Grass*** | *2-5 tons/acre* | *27 lbs/ton* | *8.9 lbs/ton* | *3.9 lbs/ton* |
| | | *(54-135 lbs/acre)* | *(18-45 lbs/acre)* | *(7.9-19.8 lbs/acre)* |

**Multiply by $P_2O_5$ by 0.44 to convert to elemental P.*

Table 2. Pipe Friction Loss (for PVC pipe).

| | ft head loss per 100 ft of pipe | |
|---|---|---|
| | Nominal Pipe Diameter | |
| Flow (gpm) | 2 inch | 3 inch |
| 15 | 0.42 | - |
| 20 | 0.73 | - |
| 25 | 1.11 | - |
| 30 | 1.55 | 0.23 |
| 35 | 2.06 | 0.3 |
| 40 | 2.64 | 0.39 |
| 45 | 3.28 | 0.48 |
| 50 | 3.99 | 0.58 |
| 60 | 5.6 | 0.82 |
| 70 | - | 1.09 |
| 80 | - | 1.39 |
| 90 | - | 1.73 |

**Equation 1. Full-circle spray pattern with overlap.**

$$EAA = [(N_L - 1) * S_L + D] * [(N_W - 1) * S_w + D]$$

**Equation 2. Half-circle spray pattern with overlap.**

$$EAA = \frac{[(N_L - 1) * S_L + D] * D}{2}$$

$EAA$ = Effective Application Area ($ft^2$)
$N_L$ = Number of heads along the length
$N_W$ = Number of rows of heads along the width
$S_L$ = Spacing along length (ft)
$S_W$ = Spacing of width (ft)
$D$ = Diameter of spread pattern (ft)