

Examples: Sizing a Manure Storage Facility

Sizing a manure storage facility requires determination of all factors that contribute a volume component to the system. For any given manure storage facility, these factors may include one or more of the following:

- (1) Manure volume produced during the selected storage period
- (2) Bedding added or used during the selected storage period
- (3) Runoff from exposed lots and buildings during the selected storage period
- (4) Sludge accumulation during the selected storage period
- (5) Washwater or other fresh water additions during the selected storage period
- (6) Treatment volume
- (7) Rainfall-evaporation
- (8) 25-year, 24-hour storm

The detail (number of above factors) involved in sizing a manure storage facility varies with the system type. For example, an underfloor or covered manure pit does not experience the effects of rainfall, treatment is not part of the design, sludge is not allowed to accumulate, and bedding is not used. Hence, required manure storage volume may simply be the manure volume produced during the selected storage period, with perhaps some allowance for washwater used in cleaning the building. A lagoon, in contrast, may require an evaluation of all of the above items. Many states have regulatory requirements for sizing manure storage facilities, and these requirements must be followed where they exist. The assistance of a qualified person (consulting engineer, NRCS, or extension personnel) may be necessary for sizing a manure storage facility. Table 21-9 shows common types of manure storage facilities and the volume components normally associated with those facilities.

The following examples for a covered solid manure storage structure, open slurry tank, and lagoon show how the volume components in the above table are used in developing the final size (volume) for a manure storage facility. Volumes for other facility types (i.e., runoff holding pond, earthen basin, etc.) can be calculated by selecting the appropriate volume components from the table above and performing calculations similar to the examples.

PROBLEM 4

Size a solid manure storage facility (stackhouse) for broiler litter. Four buildings house 20,000 birds each. Average bird weight during growout is 2 pounds. Five flocks are grown each year with a 7-week growing cycle. Size the facility to hold the annual cleanout of the four buildings.

A manure storage facility is sized based on the sum of several factors such as manure volume, washwater use, lot runoff, rainfall-evaporation, and the 25-year, 24-hour storm.

Solid manure storage facilities are usually sized based on manure volume and bedding use.

Open slurry storage tanks are usually sized based on manure volume, washwater, rainfall-evaporation, and the 25-year, 24-hour storm.

A lagoon is usually sized based on manure volume, washwater use, lot runoff, rainfall-evaporation, sludge accumulation, treatment volume, and the 25-year, 24-hour storm.

Table 21-9. Manure storage facilities and their volume components.

Manure Storage Type	Typical Volume Components
Solid manure, not covered	1. Manure 2. Bedding (may require runoff controls)
Solid manure, covered or roofed	1. Manure 2. Bedding
Slurry pit or tank, covered	1. Manure 2. Washwater 3. Lot runoff
Slurry pit or tank, not covered	1. Manure 2. Washwater 3. Lot runoff 4. Rainfall-evaporation 5. 25-yr, 24-hr storm
Earthen basin	1. Manure 2. Washwater 3. Lot runoff 4. Rainfall-evaporation 5. Sludge or unpumpable solids 6. 25-yr, 24-hr storm
Lagoon	1. Manure 2. Washwater 3. Lot runoff 4. Rainfall-evaporation 5. Sludge volume 6. Treatment volume 7. 25-yr, 24-hr storm
Runoff holding pond	1. Lot runoff 2. 25-yr, 24-hr storm

PROBLEM 5

Size a circular slurry manure storage tank for a 3,300-head swine-finishing operation (under roof) located in central Indiana. Average pig weight is 150 lbs, and the storage period is one year. The tank will not be covered, so include storage for the 25-yr, 24-hr storm and R-E. Provide sufficient depth for 1 ft freeboard. Washwater use averages 50 gallons per day.

PROBLEM 6

Size a lagoon (365-day storage period) to serve a 300-cow dairy in central Missouri. Average cow weight is 1,400 lbs. The operation includes an exposed dirt exercise lot 1 acre in size and 12,000 square ft of exposed concrete and unguttered roof areas. Average washwater use is 10 gallons per day per cow.

WORKSHEET FOR CALCULATING PROBLEM 4

Facility type (solid storage, manure tank, lagoon) stackhouse for broiler litter
 Selected manure storage period = 5 flocks x 49 d/flock = 245 days

1. Volume of manure and bedding. Using data in Tables 21C-1 through 21C-9, Table 21-2, and Table 21-3, calculate the volume of manure and bedding for the selected storage period.

Manure:

$$\text{ft}^3 \text{d}/1,000 \# \times \text{no. animals} \times \text{lbs/animal (avg. wt.)} \times \text{storage period, d}/1,000$$

$$\underline{0.66} \times \underline{80,000} \times \underline{2.0} \times \underline{245} / 1,000 = \underline{25,872} \text{ ft}^3$$

Bedding:

$$\text{lbBedding/Kwt-d} \times \text{no. animals} \times \text{lbs/animal (avg. wt.)} \times \text{storage period, d}/1,000$$

$$\underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / 1,000 = \underline{\hspace{2cm}} \text{ lbBedding}$$

$$\text{lbBedding} \times \text{void factor (0.3-0.5)/bedding density, lb/ft}^3$$

$$\underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ ft}^3 \text{ bedding}$$

$$\underline{25,872} \text{ ft}^3 \text{ manure} + \underline{\hspace{2cm}} \text{ ft}^3 \text{ bedding} = \underline{25,872} \text{ ft}^3 \text{ manure/bedding}$$

2. Volume of lot runoff. Using data in Figures 21B-1, -2, -3a, and -3b, calculate the volume of runoff from exposed dirt lots, concrete lots, and unguttered roofs.

$$\text{dirt lot, ft}^2 \times \text{rainfall, in} \times \text{percent runoff} / 12$$

$$\underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / 12 = \underline{\hspace{2cm}} \text{ ft}^3 \text{ runoff}$$

$$\text{concrete, unguttered roofs, ft}^2 \times \text{rainfall, in} \times \text{percent runoff} / 12$$

$$\underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / 12 = \underline{\hspace{2cm}} \text{ ft}^3 \text{ runoff}$$

$$\text{ft}^3 \text{ dirt lot runoff} \underline{\hspace{2cm}} + \text{ft}^3 \text{ concrete, roof runoff} \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ ft}^3 \text{ total runoff}$$

3. Depth of rainfall-evaporation. Using data from Figures 21B-3a, -3b, and -4, calculate the depth of R-E on the exposed surface of the manure storage facility.

$$(\text{rainfall, in} - \text{evaporation, in}) / 12$$

$$(\underline{\hspace{2cm}} - \underline{\hspace{2cm}}) / 12 = \underline{\hspace{2cm}} \text{ ft rainfall - evaporation}$$

4. Sludge accumulation. Using data in Tables 21C-1 through 21C-10, calculate the volume of sludge accumulation.

$$\begin{aligned} & \text{TS, lb/d/1,000 \#} \times \text{no. animals} \times \text{lbs/animal (avg. wt.)} \times \text{storage period, d/1,000} \\ & \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / 1,000 = \underline{\hspace{2cm}} \text{ lb TS} \\ \\ & \text{SAR, ft}^3/\text{lb TS} \quad \times \quad \text{lb TS} \\ & \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ft}^3 \end{aligned}$$

5. Treatment volume. Using data from Tables 21C-1 through 21C-9 and Figure 21B-5, calculate treatment volume (lagoons only).

$$\begin{aligned} & \text{VS, lb/d/1,000 \#} \times \text{no. animals} \times \text{lbs/animal (avg. wt.)/1,000} \\ & \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / 1,000 = \underline{\hspace{2cm}} \text{ lb VS/d} \\ \\ & \text{lb VS/d} \quad / \quad \text{lb VS/1,000 ft}^3/\text{d} \quad \times \quad 1,000 \\ & \underline{\hspace{2cm}} / \underline{\hspace{2cm}} \times 1,000 = \underline{\hspace{2cm}} \text{ft}^3 \end{aligned}$$

6. Volume/depth of 25-year, 24-hour storm. Using data in Figure 21B-6, calculate the depth of the 25-year, 24-hour storm on the manure storage facility surface and associated runoff from exposed lot and roof areas.

$$\begin{aligned} & \text{25-yr, 24-hr storm, in/12} \\ \text{Depth} = & \underline{\hspace{2cm}} / 12 = \underline{\hspace{2cm}} \text{ ft} \\ \\ & \text{25-yr, 24-hr storm, ft} \quad \times \quad \text{exposed lot/roof area, ft}^2 \\ & \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ft}^3 \end{aligned}$$

7. Volume of washwater. Using water use data for the operation or estimating water use from similar operations, calculate the volume of washwater used during the selected storage period.

$$\begin{aligned} & \text{Washwater use, gal/day} \quad \times \quad \text{storage period, days/7.48} \\ & \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / 7.48 = \underline{\hspace{2cm}} \text{ft}^3 \end{aligned}$$

8. Total volume of manure storage facility. To obtain total manure storage facility volume, sum the applicable volumes from Steps 1 through 7 above.

$$\begin{aligned} & \text{Manure/bedding} + \text{lot runoff} + \text{sludge} + \text{treatment} + \text{25-yr, 24-hr storm} + \text{washwater} \\ & \underline{\hspace{2cm}} \text{25,872} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} \\ & = \underline{\hspace{2cm}} \text{25,872} \text{ft}^3 \text{ total volume} \end{aligned}$$

9. Determine dimensions of manure storage facility. Using the appropriate formula below, assume facility dimensions and calculate volume. Adjust dimensions by trial and error until the volume in Step 8 above is obtained.

Square or rectangular manure tank: Volume = length, ft x width, ft x depth, ft
 = 80 x 40 x 8 = 25,600 ft³

Round manure tank: Volume = diameter, ft x diameter, ft x depth, ft x 0.785
 _____ x _____ x _____ x 0.785 = _____ ft³

Square or rectangular earthen impoundments: (slope = inside or front slope of impoundment, i.e., for 3:1 slopes, slope = 3)

$$\begin{aligned} \text{Volume} &= \text{length, ft} \times \text{width, ft} \times \text{depth, ft} \\ &= \text{_____} \times \text{_____} \times \text{_____} \\ &- \text{slope} \times \text{depth, ft} \times \text{depth, ft} \times (\text{length, ft} + \text{width, ft}) \\ &- \text{_____} \times \text{_____} \times \text{_____} \times (\text{_____} + \text{_____}) \\ &+ 4 \times \text{slope} \times \text{slope} \times \text{depth, ft} \times \text{depth, ft} \times \text{depth, ft} / 3 \\ &+ 4 \times \text{_____} \times \text{_____} \times \text{_____} \times \text{_____} \times \text{_____} / 3 \\ &= \text{_____} \text{ ft}^3 \end{aligned}$$

Depths of R-E; the 25-year, 24-hour storm; and freeboard, if applicable, must be added to the manure storage facility depth determined above.

Step 3		Step 6		
R-E, ft	+	25-yr, 24-hr storm, ft	+	freeboard, ft
_____	+	_____	+	_____
				= _____ ft added depth

This will increase the final length and width (at the top inside edge) of earthen impoundments according to the following formulas:

New length = old length, ft + (added depth, ft x slope x 2)
 = _____ + (_____ x _____ x 2) = _____ ft

New width = old width, ft + (added depth, ft x slope x 2)
 = _____ + (_____ x _____ x 2) = _____ ft

Final depth = preliminary depth, ft + added depth, ft
 = _____ + _____ = _____ ft

This litter volume could be contained in a structure 40 ft wide by 80 ft long with a stacking depth of 8 ft. Building length may need to be increased due to sloping pile ends.

4. Sludge accumulation. Using data in Tables 21C-1 through 21C-10, calculate the volume of sludge accumulation.

$$\text{TS, lb/d/1,000 \#} \times \text{no. animals} \times \text{lbs/animal (avg. wt.)} \times \text{storage period, d/1,000}$$

$$\underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / 1,000 = \underline{\hspace{2cm}} \text{ lb TS}$$

$$\text{SAR, ft}^3/\text{lb TS} \times \text{lb TS}$$

$$\underline{\hspace{2cm}} \times \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ ft}^3$$

5. Treatment volume. Using data from Tables 21C-1 through 21C-9 and Figure 21B-5, calculate treatment volume (lagoons only).

$$\text{VS, lb/d/1,000 \#} \times \text{no. animals} \times \text{lbs/animal (avg. wt.)/1,000}$$

$$\underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} / 1,000 = \underline{\hspace{2cm}} \text{ lb VS/d}$$

$$\text{lb VS/d} / \text{lb VS/1,000 ft}^3/\text{d} \times 1,000$$

$$\underline{\hspace{2cm}} / \underline{\hspace{2cm}} \times 1,000 = \underline{\hspace{2cm}} \text{ ft}^3$$

6. Volume/depth of 25-year, 24-hour storm. Using data in Figure 21B-6, calculate the depth of the 25-year, 24-hour storm on the manure storage facility surface and associated runoff from exposed lot and roof areas.

$$\text{25-yr, 24-hr storm, in/12}$$

$$\text{Depth} = \underline{\hspace{1cm}} \underline{5} \underline{\hspace{1cm}} / 12 = \underline{\hspace{1cm}} \underline{0.4} \underline{\hspace{1cm}} \text{ ft}$$

$$\text{25-yr, 24-hr storm, ft} \times \text{exposed lot/roof area, ft}^2$$

$$\underline{\hspace{2cm}} \times \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ ft}^3$$

7. Volume of washwater. Using water use data for the operation or estimating water use from similar operations, calculate the volume of washwater used during the selected storage period.

$$\text{Washwater use, gal/day} \times \text{storage period, days/7.48}$$

$$\underline{\hspace{2cm}} \underline{50} \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \underline{365} \underline{\hspace{2cm}} / 7.48 = \underline{\hspace{2cm}} \underline{2,440} \underline{\hspace{2cm}} \text{ ft}^3$$

8. Total volume of manure storage facility. To obtain total manure storage facility volume, sum the applicable volumes from Steps 1 through 7 above.

$$\text{Manure/bedding} + \text{lot runoff} + \text{sludge} + \text{treatment} + \text{25-yr, 24-hr storm} + \text{washwater}$$

$$\underline{\hspace{2cm}} \underline{180,675} \underline{\hspace{2cm}} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} \underline{2,440}$$

$$= \underline{\hspace{2cm}} \underline{183,115} \underline{\hspace{2cm}} \text{ ft}^3 \text{ total volume}$$

9. Determine dimensions of manure storage facility. Using the appropriate formula below, assume facility dimensions and calculate volume. Adjust dimensions by trial and error until the volume in Step 8 above is obtained.

Square or rectangular manure tank: Volume = length, ft x width, ft x depth, ft
 = _____ x _____ x _____ = _____ ft³

Round manure tank: Volume = diameter, ft x diameter, ft x depth, ft x 0.785
 _____ 120 _____ x _____ 120 _____ x _____ 16 _____ x 0.785 = 180,864 ft³

Square or rectangular earthen impoundments: (slope = inside or front slope of impoundment, i.e., for 3:1 slopes, slope = 3)

$$\begin{aligned} \text{Volume} &= \text{length, ft} \times \text{width, ft} \times \text{depth, ft} \\ &= \text{_____} \times \text{_____} \times \text{_____} \\ &- \text{slope} \times \text{depth, ft} \times \text{depth, ft} \times (\text{length, ft} + \text{width, ft}) \\ &- \text{_____} \times \text{_____} \times \text{_____} \times (\text{_____} + \text{_____}) \\ &+ 4 \times \text{slope} \times \text{slope} \times \text{depth, ft} \times \text{depth, ft} \times \text{depth, ft} / 3 \\ &+ 4 \times \text{_____} \times \text{_____} \times \text{_____} \times \text{_____} \times \text{_____} / 3 \\ &= \text{_____} \text{ ft}^3 \end{aligned}$$

Depths of R-E; the 25-year, 24-hour storm; and freeboard, if applicable, must be added to the manure storage facility depth determined above.

Step 3	Step 6			
R-E, ft	+	25-yr, 24-hr storm, ft	+	freeboard, ft
<u>0.6</u>	+	<u>0.4</u>	+	<u>1.0</u>
= <u>2.0</u> ft added depth				

According to the following formulas, this will increase the final length and width (at the top inside edge) of earthen impoundments.

New length = old length, ft + (added depth, ft x slope x 2)
 = _____ + (_____ x _____ x 2) = _____ ft

New width = old width, ft + (added depth, ft x slope x 2)
 = _____ + (_____ x _____ x 2) = _____ ft

Final depth = preliminary depth, ft + added depth, ft
 = 16.0 + 2.0 = 18.0 ft

Volume with 1-ft freeboard = 120 x 120 x 0.785 x 17 = 192,168 ft³

Thus, a tank 120 ft in diameter and 18 ft deep would provide the desired storage. Manufacturer's standard sizes may not be available in these exact dimensions, but the unit should be selected to provide at least the storage calculated.

WORKSHEET FOR CALCULATING PROBLEM 6

Facility type (solid storage, manure tank, lagoon) _____ dairy lagoon

Selected manure storage period = _____ 365 _____ days

1. Volume of manure and bedding. Using data in Tables 21C-1 through 21C-9, Table 21-2, and Table 21-3, calculate the volume of manure and bedding for the selected storage period.

Manure:

ft³ d/1,000 # x no. animals x lbs/animal (avg. wt.) x storage period, d/1,000
 _____ 1.3 _____ x _____ 300 _____ x _____ 1,400 _____ x _____ 365 _____ /1,000 = _____ 199,290 _____ ft³

Bedding:

lbBedding/Kwt-d x no. animals x lbs/animal (avg. wt.) x storage period, d/1,000
 _____ x _____ x _____ x _____ /1,000 = _____ lbBedding

lbBedding x void factor (0.3-0.5)/bedding density, lb/ft³
 _____ x _____ / _____ = _____ ft³ bedding

_____ 199,290 _____ ft³ manure + _____ ft³ bedding = _____ 199,290 _____ ft³ manure/bedding

2. Volume of lot runoff. Using data in Figures 21B-1, -2, -3a, and -3b, calculate the volume of runoff from exposed dirt lots, concrete lots, and unguttered roofs.

dirt lot, ft² x rainfall, in. x percent runoff /12
 _____ 43,560 _____ x _____ 38 _____ x _____ 0.27 _____ /12 = _____ 37,244 _____ ft³ runoff

concrete, unguttered roofs, ft² x rainfall, in x percent runoff /12
 _____ 12,000 _____ x _____ 38 _____ x _____ 0.58 _____ /12 = _____ 22,040 _____ ft³ runoff

ft³ dirt lot runoff _____ 37,244 _____ + ft³ concrete, roof runoff _____ 22,040 _____ = _____ 59,284 _____ ft³ total runoff

3. Depth of rainfall-evaporation. Using data from Figures 21B-3a, -3b, and -4, calculate the depth of R-E on the exposed surface of the manure storage facility.

(rainfall, in - evaporation, in)/12
 (_____ 38 _____ - _____ 38 _____) /12 = _____ 0.0 _____ ft R-E

4. Sludge accumulation. Using data in Tables 21C-1 through 21C-10, calculate the volume of sludge accumulation.

$$\text{TS, lb/d/1,000 \#} \times \text{no. animals} \times \text{lbs/animal (avg. wt.)} \times \text{storage period, d/1,000}$$

$$\underline{10.0} \times \underline{300} \times \underline{1,400} \times \underline{365} / 1,000 = \underline{1,533,000} \text{ lb TS}$$

$$\text{SAR, ft}^3/\text{lb TS} \times \text{lb TS}$$

$$\underline{0.0729} \times \underline{1,533,000} = \underline{111,756} \text{ ft}^3$$

5. Treatment volume. Using data from Tables 21C-1 through 21C-9 and Figure 21B-5, calculate treatment volume (lagoons only).

$$\text{VS, lb/d/1,000 \#} \times \text{no. animals} \times \text{lbs/animal (avg. wt.)/1,000}$$

$$\underline{8.5} \times \underline{300} \times \underline{1,400} / 1,000 = \underline{3,570} \text{ lb VS/d}$$

$$\text{lb VS/d} / \text{lb VS/1,000 ft}^3/\text{d} \times 1,000$$

$$\underline{3,570} / \underline{5.0} \times 1,000 = \underline{714,000} \text{ ft}^3$$

6. Volume/depth of 25-year, 24-hour storm. Using data in Figure 21B-6, calculate the depth of the 25-year, 24-hour storm on the manure storage facility surface and associated runoff from exposed lot and roof areas.

$$\text{25-yr, 24-hr storm, in/12}$$

$$\text{Depth} = \underline{6} / 12 = \underline{0.5} \text{ ft}$$

$$\text{25-yr, 24-hr storm, ft} \times \text{exposed lot/roof area, ft}^2$$

$$\underline{0.5} \times \underline{55,560} = \underline{27,780} \text{ ft}^3$$

7. Volume of washwater. Using water use data for the operation or estimating water use from similar operations, calculate the volume of washwater used during the selected storage period.

$$\text{Washwater use, gal/day} \times \text{storage period, days/7.48}$$

$$\underline{3,000} \times \underline{365} / 7.48 = \underline{146,390} \text{ ft}^3$$

8. Total volume of manure storage facility. Sum the applicable volumes from Steps 1 through 7 above to obtain total manure storage facility volume.

$$\text{Manure/bedding} + \text{lot runoff} + \text{sludge} + \text{treatment} + \text{25-yr, 24-hr storm} + \text{washwater}$$

$$\underline{199,290} + \underline{59,284} + \underline{111,756} + \underline{714,000} + \underline{27,780} + \underline{146,390}$$

$$= \underline{1,258,500} \text{ ft}^3 \text{ total volume}$$

9. Determine dimensions of manure storage facility. Using the appropriate formula below, assume facility dimensions and calculate volume. Adjust dimensions by trial and error until the volume in Step 8 above is obtained.

Square or rectangular manure tank: Volume = length, ft x width, ft x depth, ft
 = _____ x _____ x _____ = _____ ft³

Round manure tank: Volume = diameter, ft x diameter, ft x depth, ft x 0.785
 _____ x _____ x _____ x 0.785 = _____ ft³

Square or rectangular earthen impoundments: (slope = inside or front slope of impoundment, i.e., for 3:1 slopes, slope = 3)

$$\begin{aligned} \text{Volume} &= \text{length, ft} \times \text{width, ft} \times \text{depth, ft} \\ &= \underline{500} \times \underline{250} \times \underline{13} \\ &- \text{slope} \times \text{depth, ft} \times \text{depth, ft} \times (\text{length, ft} + \text{width, ft}) \\ &- \underline{3} \times \underline{13} \times \underline{13} \times (\underline{500} + \underline{250}) \\ &+ 4 \times \text{slope} \times \text{slope} \times \text{depth, ft} \times \text{depth, ft} \times \text{depth, ft} / 3 \\ &+ 4 \times \underline{3} \times \underline{3} \times \underline{13} \times \underline{13} \times \underline{13} / 3 \\ &= \underline{1,271,114} \text{ ft}^3 \end{aligned}$$

Depths of R-E, the 25-year, 24-hour storm, and freeboard, if applicable, must be added to the manure storage facility depth determined above.

Step 3		Step 6				
R-E, ft	+	25-yr, 24-hr storm, ft	+	freeboard, ft		
<u>0</u>	+	<u>0.5</u>	+	<u>2.0</u>		
				=	<u>2.5</u>	ft added depth

According to the following formulas, this will increase the final length and width (at the top inside edge) of earthen impoundments.

New length = old length, ft + (added depth, ft x slope x 2)
 = 500 + (2.5 x 3 x 2) = 515 ft

New width = old width, ft + (added depth, ft x slope x 2)
 = 250 + (2.5 x 3 x 2) = 265 ft

Final depth = preliminary depth, ft + added depth, ft
 = 13 + 2.5 = 15.5 ft

Geological characteristics (depth to groundwater or bedrock) and other applicable site limitations should be considered in selecting lagoon dimensions.