



# Module 5: **Animals, Animal Byproducts, Biosolids and Site Selection**

## Acknowledgments

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## **Module 5: Animals, Animal Byproducts, Biosolids and Site Selection**

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**Estimated duration:** 1 – 1.5 hour

### **Instructional overview**

Participants train growers to implement Good Agricultural Practices (GAPs) that protect public health without unnecessarily burdening farmers.

### **Instructional objectives**

Participants will increase their knowledge of the following:

- Why food safety-related GAPs are important
- GAPs related to domestic and wild animals
- GAPs for use of animal byproducts and biosolids
- GAPs for site selection

### **Equipment, supplies, and materials needed:**

- Laptop
- PowerPoint (PPT) presentation on CD
- LCD projector
- Nametags, pens, sign-in sheet
- Copies of case study, pre-test and post-test for participants

### **Preparation needed:**

- Review Module 3 and PPT prior to day of the workshop.
- Become familiar with GAPs programming—how each module is an integral part of the other eight modules.
- Arrange room for optimal participation.
- Secure a laptop computer with PowerPoint capability and an LCD projector. Save a copy of the presentation (from CD) on the computer. Make copies of case study, pre-test and post-test for all participants. Have a copy of the case study with answers for yourself.
- Prepare room to accommodate participants and projector. Have sign in sheet and nametags, as applicable.



**Module 5:**  
**Animals, Animal Byproducts,  
Biosolids and Site Selection**

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### Acknowledgments

- Karl Shaffer – Dept. of Soil Science, NCSU
- Alexandria Graves – Dept. of Soil Science, NCSU
- Fletcher Arritt – Dept. of Food, Bioprocessing and Nutrition Sciences, NCSU
- Rhonda Sherman – Dept. of Biological and Agricultural Engineering, NCSU
- Deanna Osmond – Dept. of Soil Science, NCSU
- Chris Gunter – Dept. of Horticultural Science, NCSU
- Billy Little – N.C. Cooperative Extension, Wilson County Center



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### Topics

- Goals
- Why should I care?
- General considerations
- Good Agricultural Practices (GAPs)
  - Animals
  - Manure and compost
  - Other animal byproducts
  - Biosolids
  - Site selection
- Case study
- Summary



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## Module 5

### Welcome

Have participants make nametags and introduce themselves

### Teaching procedures

Use Module 5 PPT to lead class discussion.

### PPT 5-1: Module 5: Animals, Animal By-products, Biosolids and Site Selection

The topic of food-borne illness has been in the media and had the attention of consumers and the government during the last several years (*adjust wording, if necessary, when this presentation is given*). Good Agricultural Practices (GAPs) for fresh produce, along with Good Handling Practices, can help prevent food-borne illness. This presentation addresses GAPs related to animals, animal byproducts, biosolids and site selection.

### PPT 5-2: Acknowledgments

(Flip through)

### PPT 5-3: Topics

Here are the topics we're going to cover during this module. I'll talk some about the goals for this module, why we might care about these GAPs, and some general considerations about the topic; and then we'll get into GAPs related to animals and animal byproducts, biosolids and site selection. There will be a case study, summary and post-test at the end.

## Topics

- **Goals**
- Why should I care?
- General considerations
- Good Agricultural Practices (GAPs)
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### PPT 5-4: Topics (Flip through)

## Goals

Participants will increase their knowledge of:

- Why GAPs are important
- GAPs related to domestic and wild animals
- GAPs for use of animal byproducts and biosolids
- GAPs for site selection

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### PPT 5-5: Goals

The goals for this module are for you to increase your knowledge of (1) why GAPs are important; (2) GAPs related to domestic and wild animals; (3) GAPs for use of animal byproducts and biosolids; and (4) GAPs related to site selection. The byproducts that I'll talk about include manures, composts, manure and compost teas and other amendments, such as feathermeal and blood-meal. There will be a post-test and evaluation (*or whatever you plan to use*) at the end for you to complete. It's important for us to assess the effectiveness of what we're teaching, so please complete the test and return them before you leave.

## Topics

- Goals
- **Why should I care?**
- General considerations
- GAPs
  - Animals
  - Manure and compost
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### PPT 5-6: Topics

Why should you care? Who can give me an example of a case, highly publicized or not, of a disease outbreak related to fresh produce? (*Possible answers include Salmonella, 2008; E. coli O157:H7 on spinach, 2006; etc.*)

## Possible Sources of *E. coli* O157:H7 in 2006 Spinach Outbreak

- Feces from wild pigs in field
- Irrigation water (ground water) recharged by river, which was contaminated by feces from cows and/or pigs

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### **PPT 5-7: Possible Sources of *E. coli* in 2006 Spinach Outbreak**

There have been several highly publicized fresh produce-related disease outbreaks during the last several years (*adjust wording, if necessary, when this presentation is given*), and the California spinach case of 2006 was one of the most prominent. The final report on it points to possible manure-related routes of contamination. The implicated strain of *E. coli* O157:H7 was found in cattle feces along the river running through the property, in river water and sediment, in wild pig feces (there was a large population of wild pigs in the area), and in pasture soil.

### **PPT 5-7 (continued)**

*E. coli* O157:H7 could have gotten into the field directly, from the wild pigs, or indirectly, from cattle or other animals on the farm or upstream. Animals were able to get into the river water, which may have recharged the groundwater while its level was lower than that of the river. The river has been known by the state to have fecal coliform issues. Ground water that may have been contaminated by bacteria in river water was used for overhead irrigation of the spinach.

Irrigation water had been tested near the beginning of the season, but the water table became lower over the course of the growing season, and contaminated river water may have entered after the wells were tested. Bagged spinach was the problem in this case, and it's possible that the *E. coli* spread among the spinach leaves during processing, compounding the problem. However, the source of the *E. coli* is believed to have been in the field.

(California Food Emergency Response Team, 2007)

## How Might This Have Been Prevented?

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### **PPT 5-8: How Might This Have Been Prevented?**

(Ask audience:) How might this public health crisis have been prevented?

Some possible answers, if they're not mentioned, are as follows:

- better efforts to keep out wild pigs (there was some fencing, but there were places where wild pigs may have gotten through)
- removal of pig habitat
- more frequent testing of well water
- keeping cattle out of river water that may have recharged groundwater
- not using overhead irrigation.

## Why Should I Care?

- Public health
- Loss of sales (self and others)
- Lawsuits
- Pass buyer-mandated audits
- Avoid required audits

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### PPT 5-9: Why Should I Care?

Why should we, and others who work in agriculture, care about how this happened and what might be done to prevent similar incidents?

First, of course, public health is important, and we should do our part to keep people from getting sick.

Second, food-borne diseases have financial consequences. As a result of the spinach-related *E. coli* O157:H7 outbreak, spinach sales dropped dramatically. This incident didn't just affect the farm where the problem originated but the whole industry.

As an example of litigation related to fresh

### PPT 5-9 (continued)

produce-related sickness, one law firm alone represented 93 of the victims in the spinach case (Marler Clark, n.d.). This firm, Marler-Clark, specializes in food-borne illness litigation.

Many grocery chains and large buyers now require that their suppliers pass food safety audits, and knowledge of GAPs is needed to pass them. At this time, there is no federal or state requirement for North Carolina growers who sell produce to pass audits, but it is possible that such legislation could occur in the future (*true at time of writing—adjust for current state, if necessary*). Perhaps by preventing outbreaks of disease related to food safety, growers can avoid legislation resulting in costly government oversight.

## Topics

- Goals
- Why should I care?
- **General considerations**
- Good Agricultural Practices
  - Animals
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### PPT 5-10: Topics

Now, we're going to talk about a few general considerations before moving into specific GAPs.

## Pathogens

- Organisms that cause disease
- Often carried in feces

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### PPT 5-11: Pathogens

Pathogens are organisms that cause disease. Many pathogens implicated in fresh produce-related, food-borne illness can be carried in animal or human waste. While this presentation covers animals and animal byproducts in general, the concern associated with animals is primarily related, directly or indirectly, to fecal material. So, the subjects of manures and biosolids are essential to a thorough education about GAPs.

## The “Guide” Says...

“Fresh produce can become microbiologically contaminated at any point along the farm-to-table food chain. The major source of microbial contamination with fresh produce is associated with human or animal feces.”

Basic Principle 3, from “Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables”

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### PPT 5-12: The “Guide” Says...

The third basic principle in the “Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables” is that contamination can occur anywhere along the way, but it is usually associated with animal or human waste.

## Pathogens

- Spread onto surface of plants from amendment or amended soil (possibly to inside of fruit)
- Uptake by roots

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### PPT 5-13: Pathogens

Pathogens can move from amendments, such as manure, or amended soil onto the surface of plants and either remain on the surface or end up inside the fruit. Pathogens can enter the fruit part of a plant through the flower or stem end or where it is injured. (*Note: “Fruit” is used in the botanical sense—can include tomatoes, peppers, squash, etc.*) There is also some concern about pathogens being taken up through roots: Uptake of *E. coli* into the above-ground part of lettuce has been documented in some, but not all, experiments on the question (Johannessen et al., 2004; Solomon and Matthews, 2005; Solomon et al., 2002; Wachtel et al., 2002).

**The Goal**

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Unless noted, photos courtesy of USDA ARS Image Gallery

**PPT 5-14: The Goal**

The goal of these GAPs is to prevent pathogens from getting from feces into food.

**Crop Characteristics**

- How much contact is there between the edible part and potential contaminant?
- Is the crop generally cooked before consumption?

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**PPT 5-15: Crop Characteristics**

The risk associated with a particular type of produce is related in part to characteristics of the produce itself and how it is eaten. One consideration is the amount of contact between the eaten part of the plant and the potential source of contamination. If the concern is manure that has been applied to the soil, carrots growing underground and strawberries resting on or near the soil are intuitively of greater concern than sweet corn or tree fruits that grow above the soil. On the other hand, if potentially contaminated overhead irrigation water is used, crops with the eaten part above ground may be subject to greater risk.

**PPT 5-15 (continued)**

The risk also depends on whether the eaten part is cooked before it is consumed, although growers cannot be sure how someone will prepare what they grow.

**Topics**

- Goals
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**PPT 5-16: Topics**

Now we're going to get into GAPs in specific areas. Some of these guidelines may seem commonsense, and they are. In many cases, unfortunately, we don't have as much specific research-based information as needed. Furthermore, many factors can affect situations, making it virtually impossible to tell you, for example, exactly how far a crop should be from livestock or how many days before harvest manure should be applied. However, we can give you information on ways to reduce your risk. As we go through these topics, we're also going to address some related laws and audit questions. However, more detailed information should be obtained from the auditing agency if a grower is considering getting an audit. I can provide you with links to audit examples.

## Topics

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### **PPT 5-17: Topics**

Animals are often the source of the pathogens that cause outbreaks of food-borne disease, so one good agricultural practice is to keep animals away from produce as much as possible.

## Livestock

- Prevent livestock, manure and contaminated runoff from coming in contact with produce or irrigation water.
- A number of variables affect needed distance between animals and crop or water source.

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### **PPT 5-18: Livestock**

First, try to minimize the chance that farm animals, their manure or runoff from livestock areas will come into contact with produce or irrigation water.

Many factors affect the actual risk of livestock areas to produce: the slope of the land; relative elevations of livestock and crops or irrigation water; the vegetation between livestock and crops or irrigation water; the type of crop (as discussed earlier); and others. Therefore, it is impossible to say exactly how far livestock should be from produce or water sources in every situation. Keep in mind that the point is to prevent manure, including manure-contaminated water, from getting into the production field and onto the eaten part of the crop.

## Livestock

- USDA and Primus ranch audits ask questions regarding the proximity of domestic animals to fields.
- Leafy Greens Marketing Agreement checklists ask whether crops are 30' from grazing lands and domestic animals, 400' from CAFOs.

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### **PPT 5-19: Livestock (cont'd)**

The United States Department of Agriculture (USDA) and Primus ranch audits question the proximity of different types of domestic animals to the cropland. The Leafy Greens Marketing Agreement audit is the only one that includes numbers in this context. It asks if the crop is at least 30 feet away from grazing lands or domestic animals and at least 400 feet from "concentrated animal feeding operations."

## Livestock

CAFOs are non-vegetated areas that have at least a minimum number of animals (e.g., 200 mature dairy cows; 300 heifers, steers or bulls; 750 swine of greater than 55 pounds; 150 horses; 9,000 chickens [when a liquid manure-handling system is used]), or have been identified as "...a significant contributor of pollutants to waters of the United States." (40CFR122.23)

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### PPT 5-20: Livestock (cont'd)

Defined by the Clean Water Act, the term "concentrated animal feeding operations," or CAFO, means non-vegetated areas that have at least a minimum number of animals, or have been identified as "...a significant contributor of pollutants to waters of the United States." (*More information: 40CFR122.23* - [http://edocket.access.gpo.gov/cfr\\_2003/julqtr/40cfr122.23.htm](http://edocket.access.gpo.gov/cfr_2003/julqtr/40cfr122.23.htm) )

Many North Carolina livestock operations do not fall into this category. However, a higher concentration of animals may pose a greater risk because of the larger amount of manure that they will produce in one area and the greater chance that at least one animal will carry a pathogen.

## Livestock



Photo from presentation by Doug Sanders

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### PPT 5-21: Livestock (cont'd)

This appears to be a non-vegetated area that has held a large number of livestock.

## Livestock



Photo from presentation by Doug Sanders

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### PPT 5-22: Livestock (cont'd)

There is a livestock facility barely visible at the top of this hill, posing a potential risk to downhill produce.

## Livestock



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### **PPT 5-23: Livestock (cont'd)**

A field such as this might provide some risk to a production field down-slope, but vegetation and a less dense animal population may make it less of a risk than high-density facilities.

## Pets

- Keep pets out of field during growing season, using barriers as necessary.
- Animals can bring not only their waste but can carry pathogens from the waste of other animals.

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### **PPT 5-24: Pets**

According to “The Guide,” growers should avoid letting pets in fields during the growing season. Animals may carry pathogens not only from their own waste but also from other sources with which they have been in contact, such as manure, water and soil.

## Wild Animals

- Watch out for evidence of large populations of wild animals.
- Fencing, scare tactics, depredation and/or modification of the surrounding environment are potential management measures.

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### **PPT 5-25: Wild Animals**

In addition to taking precautions related to domestic animals, watch out for evidence of large wild animal populations near produce and irrigation ponds, and implement management practices if needed. It is virtually impossible to prevent contact with feces of all wild animals, especially birds, unless one is growing produce in a greenhouse. However, control measures—such as fencing, depredation, scare tactics or making the surrounding environment less attractive to animals—may be advisable if it appears that wild animals are particularly abundant. Tall vegetation and the presence of equipment or garbage may encourage the wild animals to gather.

## Wild Animals



Trevor Suslow, UC Davis

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### PPT 5-26: Wild Animals (cont'd)

Wild animals may be more of a threat after the harvest, when harvested produce is concentrated in one area, than when the produce is in the field. While trees can be a source of shade for harvested produce, they also provide a perch for birds. Keep birds from perching above or around harvested produce, and follow GAPs related to rodents in post-harvest facilities.

## Domestic and Wild Animals

- USDA audit
  - “Measures are taken to restrict access of livestock to the source or delivery system of crop irrigation water” and “...to reduce the opportunity for wild and/or domestic animals to enter crop production areas.”
  - “Crop production areas are monitored for the presence or signs of wild or domestic animals entering the land.”

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### PPT 5-27: Domestic and Wild Animals

The USDA audit asks whether “[m]easures are taken to restrict access of livestock to the source or delivery system of crop irrigation water” and “to reduce the opportunity for wild and/or domestic animals to enter crop production areas.” It further inquires whether “[c]rop production areas are monitored for the presence or signs of wild or domestic animals entering the land.”

## Domestic and Wild Animals

- Primus: policy prohibiting animals in areas of production or packaging/equipment storage
- LGMA: evidence of animals of significant risk

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### PPT 5-28: Domestic and Wild Animals

The Primus ranch audit asks whether or not a documented policy exists prohibiting animals in areas of production, packaging and equipment storage.

The Leafy Greens Marketing Agreement audit asks about evidence, including downed fencing, tracks, feeding or feces of “animals of significant risk.”

## Topics

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**PPT 5-29: Topics**  
(Flip through.)

## Manure

- Valuable source of nutrients but potential source of pathogens
- Take measures to reduce risk of using



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**PPT 5-30: Manure**

Manure is highly valuable as a fertilizer, but it can contain human pathogens. It is more likely to contain pathogens than synthetic fertilizers, of course, since they are not derived from animal sources. There are measures that can be taken to reduce the risk of using manure.

## The “Guide” Says...

“Practices using animal manure or municipal biosolid wastes should be managed closely to minimize the potential for microbial contamination of fresh produce.”

*Basic Principle 5, Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*



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**PPT 5-31: The “Guide” Says...**

One of the Guide’s principles is that precautions to minimize risk should be taken when using manure or biosolids.

## Raw Manure

- Apply early, keeping nutrient concerns in mind.
- Don't apply manure or manure-containing litter while eaten part is present.
- Cornell GAPs suggest applying and incorporating manure at least 120 days before harvest.

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### PPT 5-32: Raw Manure

Maximize the amount of time between manure application and harvest; apply it earlier rather than later, as far as practical and environmentally sound. Keep in mind that considerable amounts of nitrogen may become available when the crop isn't there or isn't in need of it, so you may need to reduce the amount of manure applied and/or plant a cover crop to keep nutrients in the root zone where they're needed.

Do not apply manure, or manure-containing bedding, while the part of the crop to be eaten is present. Cornell's GAPs materials suggest a length of at least 120 days between incorporation and harvest for annual crops. They also suggest that

### PPT 5-32 (continued)

manure from young animals poses a greater risk than that from older animals, and that it should be composted before being used on produce fields or not used at all. (To reduce the likelihood of contamination, also make sure that poultry litter is treated properly if manure from cattle that are fed poultry litter is used. [McKinley et al., 2000].)

## Raw Manure

- Pathogen survival dependent on
  - Type of pathogen
  - Rainfall
  - Soil Moisture
  - Temperature
  - Soil type
  - Whether or not it is incorporated.

Franz et al., 2005; Guan and Holley, 2003; Ingham et al., 2005; Natvig et al., 2002; Oliver et al., 2006; Saini et al., 2003; Scott et al., 2006

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### PPT 5-33: Raw Manure (cont'd)

The amount of time that pathogens remain in the root zone depends on the type of pathogen (Guan and Holley, 2003), rainfall (Saini et al., 2003), soil moisture (Guan and Holley, 2003, Oliver et al., 2006), temperature (Guan and Holley, 2003), and soil type (Franz et al., 2005; Ingham et al., 2005; Natvig et al., 2002; Scott et al., 2006). Whether or not manure is incorporated may affect pathogen die-off, as well (Oliver et al., 2006; Saini et al., 2003).

## Raw Manure

- Incorporation may lead to longer pathogen survival. (Oliver et al., 2006; Saini et al., 2003)
- Avoid runoff if manure is left on surface for a time.
- Incorporation may reduce chance of contamination by soil splash and reduce chance of runoff into water sources.
- Mulches reduce soil splash.

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### PPT 5-34: Raw Manure (cont'd)

Research shows that incorporation of manure or biosolids into the soil does not necessarily reduce the numbers of bacteria in the soil (Eamens et al., 2006; Oliver et al., 2006; Saini et al., 2003). Indeed, bacteria may actually survive longer when incorporated (Oliver et al., 2006; Saini et al., 2003). If growers choose to leave manure on the soil surface for a time, they should take measures, if needed, such as planting cover crops or buffers around the field to avoid runoff.

However, for above-ground crops, it seems that incorporation would reduce the risk of pathogen-

### **PPT 5-34 (continued)**

contaminated soil splashing onto produce and reduce the risk of runoff into water sources. Plastic or organic mulches assist in preventing soil splash and may be helpful.

## Raw Manure

- A DENR permit is required for manure disposal if owners have at least:
  - 75 horses
  - or 100 dairy cows
  - or 250 hogs
  - or 1,000 sheep
  - or 30,000 broilers or layers (liquid waste systems)



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### **PPT 5-35 Raw Manure (cont'd)**

People who own more than a certain numbers of livestock animals must have N.C. Division of Water Quality permits for manure application.

## Raw Manure

- N.C. DENR manure permits specify how early manure must be applied:
  - Before growing season (annual crops)
  - While dormant (fruit trees)
  - At least 30 days before harvest (produce to be processed).



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### **PPT 5-36: Raw Manure (cont'd)**

For produce that is consumed directly without being processed, these permits do not allow manure to be applied to a field during a crop's growing season or after fruit trees break dormancy. There is only a 30-day-from-harvest restriction for produce that undergoes processing but is still consumed directly by humans. (N.C. Division of Water Quality, 2007)

## Raw Manure

- USDA National Organic Program regulations specify how early manure must be incorporated:
  - 120 days before harvest for crops if the consumed part comes into contact with soil particles
  - 90 days before harvest if the consumed part does not come into contact with soil particles.



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### **PPT 5-37: Raw Manure (cont'd)**

National Organic Program regulations specify that uncomposted manure must be applied and incorporated at least 120 days from harvest, if the consumed part of the crop comes into contact with soil particles, and 90 days from harvest if the consumed part does not come into contact with soil particles.

## Raw Manure

- USDA audit asks: "...incorporated at least 2 weeks prior to planting [and] 120 days prior to harvest"?
- LGMA checklist asks: "applied in last 1 year"?

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### PPT 5-38: Raw Manure (cont'd)

The USDA audit checklist asks if raw manure has been incorporated at least 120 days before harvest and two weeks before planting. The Leafy Greens Marketing Agreement checklist asks if raw or partially composted manure has "been applied in the last 1 year."

## Raw Manure

- Primus checklist:
  - Is raw manure incorporated before planting or bud burst and at least 120 days before harvest, if use allowed by law?
  - Is there documentation of when raw manure was applied and contents of manure?

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### PPT 5-39: Raw Manure (cont'd)

The Primus ranch audit checklist asks whether raw manure is incorporated before planting or tree fruit bud break and at least 120 days before harvest. It acknowledges that more strict guidelines may be in place in some cases, as under the Leafy Greens Marketing Agreement. The audit inquires into documentation about when manure was applied and the contents of the manure.

## Raw Manure

- Avoid contaminating irrigation water, crops, finished compost or other materials with raw manure.

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### PPT4-40: Raw Manure (cont'd)

In addition to taking precautions when using raw manure, take care *before* using it, too. Store manure in a place where it or its runoff will not contaminate crops, irrigation water, finished compost or other materials that are ready to go into the field. Keep in mind that it could move by water or wind. Water-diversions such as ditches, terraces or ponds may be helpful, as might a windbreak. To avoid cross-contamination, clean equipment after using it in manure or unfinished compost and before using it in the field or in materials ready to go to the field.

## Manure Treatment Methods

- Aging (passive)
- Composting (active)
- Other active treatments
  - Pasteurization
  - Heat drying
  - Aerobic and anaerobic digestion
  - Alkali stabilization

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### PPT 5-41: Manure Treatment Methods

Aged or composted manure is preferable to fresh manure. Both of these processes can reduce pathogen numbers, but, in the active process of composting, conditions can be manipulated to increase the killing of pathogens. Pasteurization, heat drying, aerobic and anaerobic digestion and alkali stabilization are additional methods of actively reducing pathogen numbers, but composting is probably the most common.

## Composted Manure

Composting guidelines often based on federal biosolids law (40CFR503):

- At or above 131°F for at least three (within-vessel or static aerated pile) or 15 (windrow) days
- Turned at least five times (windrow only)

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### PPT 5-42: Composted Manure

One set of widely accepted composting guidelines is found in the federal biosolids regulations (40CFR503). These specify that the material is to remain at or above 131°F for at least three or 15 days, depending on the method used, and that it is to be turned at least five times if composting is done by the windrow method.

## Composted Manure

North Carolina law requires commercial compost facilities that handle manure to meet the criteria on the previous slide.

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### PPT 5-43: Composted Manure (cont'd)

While North Carolina law does not require a permit for farmers to compost materials from their own land and use it on their own farms, operations that compost manure to sell are required to be permitted and to meet the time, temperature and turning criteria stipulated on the previous slide. (15A NCAC 13B)

## Composted Manure

- USDA audit:
  - Is composted manure “properly treated, composted, or exposed to environmental conditions that would lower the expected level of expected pathogens”?
  - Are “[a]nalysis reports...available”?

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## Composted Manure

- Primus checklist:
  - Incorporation before planting/bud break
  - Applied at least 45 days before harvest
  - Documentation of when used

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## Composted Manure

- Primus checklist (cont.):
  - Certificate(s) of Analysis showing
    - Results of heavy metals test(s)
    - Less than 1000 MPN/gram fecal coliform
    - *Salmonella* under detection limit
    - *E. coli* O157:H7 under detection limit
  - Documentation that compost producer has quality-control procedures

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### PPT 5-44: Composted Manure (cont'd)

The USDA audit asks if manure was “...properly treated, composted, or exposed to environmental conditions that would lower the expected level of expected pathogens” and for “[a]nalysis reports.”

### PPT 5-45: Composted Manure (cont'd)

The Primus ranch audit checklist asks if compost was incorporated before planting or fruit tree bud break and applied at least 45 days before harvest. It asks for documentation of when the compost was used.

### PPT 5-46: Composted Manure (cont'd)

In addition, the Primus ranch audit asks for documentation of heavy metal and microbial test results on each compost lot. Results of fecal coliform, *Salmonella* and *E. coli* O157:H7 tests are requested. Growers are also asked for documentation of compost suppliers' standard operating procedures regarding cross-contamination and logs of turning and temperature activities.

*(Note: Someone may ask where such tests can be done. One North Carolina service provider is Microbac Laboratories Inc.'s Southern Testing and Research Division in Wilson (often referred to as Southern Testing). Of course, "The use of brand names in this publication does not imply endorsement by the North Carolina Cooperative Extension Service of the products or services named nor discrimination against similar products or services not mentioned." There are other service providers as well.)*

## Composted Manure

- LGMA checklist:
  - Records documenting one of following:
    - Enclosed or within -vessel composting
      - At least 131 °F for three days
    - Windrow composting
      - Aerobic conditions and at least 131 °F for 15 days
      - Turned at least five times
    - Aerated static pile composting
      - 6 - 12 in. of "insulating materials"
      - At least 131 °F for three days

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## Composted Manure

- LGMA checklist (cont'd):
  - Application 45 days before harvest
  - Lots tested and found to be in compliance
    - Less than 1000 MPN/gram fecal coliform
    - No *E. coli* 0157:H7 detected
    - No *Salmonella* detected

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## Composted Manure

- Once compost is finished, protect it from contamination.
- USDA: "Composted manure and/or treated biosolids are properly stored and are protected to minimize recontamination."

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### PPT 5-47: Composted Manure (cont'd)

The Leafy Greens Marketing Agreement checklist asks questions related to whether or not composting was done according to guidelines similar to those in the federal biosolids regulation mentioned in slide 42.

### PPT 5-48: Composted Manure (cont'd)

The checklist also asks if the compost was applied at least 45 days before harvest and for results of laboratory tests showing that each lot of compost meets certain criteria for microbial safety.

### PPT 5-49: Composted Manure (cont'd)

Watch out for possible recontamination of finished compost by animals or equipment. Clean equipment after using it in manure or unfinished compost and before using it in finished compost.

## Composted Manure

- If compost isn't produced in a satisfactory way, precautions similar to those for raw manure can be used.
- Concern about compost is related to animal materials

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### PPT 5-50 : Composted Manure (cont'd)

If there is concern that compost has not been sufficiently treated, use the same precautions as those used with manure.

When compost is made only from plant-based materials and stored properly, so as to avoid contamination, the precautions for manure-based composts are not all necessary. However, the Primus ranch audit and the Leafy Greens Marketing Agreement checklist ask for documentation that compost does not contain animal manure, when that is claimed.

## Manure Slurry

- Faster decline in *E. coli* and *Salmonella* numbers in slurry than solid manure at temps between approximately 70° and 100°F (Guan and Holley, 2003; Oliver et al., 2006)
- Cornell: Store 60 days before application in summer (90 in winter)
- Same N.C. permit requirements as manure

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### PPT 5-51: Manure Slurry

*E. coli* numbers have been found to decline more quickly in manure slurry than in solid manure, at temperatures from approximately 60° – 100°F (Guan and Holley, 2003; Oliver et al., 2006). The same was found for *Salmonella* between approximately 70° and 100°F (Guan and Holley, 2003). Precautions should still be taken. Cornell GAPs materials recommend storing slurry by itself for 60 days in summer and 90 days in winter before applying it to produce fields. Make sure that the storage area is secure and, as with manure and compost, avoid cross-contamination by equipment.

## Manure and Compost Teas

- No manure teas
- Compost tea safety dependent on compost used and protection from contamination
- Heat treatment possible

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### PPT 5-52: Manure and Compost Teas

The Cornell GAPs program recommends not using manure teas at all, although heat-treating manure tea to kill pathogens may be feasible. The safety of compost tea will depend on whether the compost itself is produced in such a way that pathogens were killed, and whether recontamination is prevented. If growers are thinking about using compost tea, they can get it tested by a laboratory to ensure that pathogens have not survived the production and storage process. Some heat treatments may successfully kill pathogens but may also eliminate bacteria theorized to combat plant diseases. In these cases, an alternative disease-management strategy may be necessary.

### **PPT 5-52 (continued)**

The Primus ranch self-audit and the Leafy Greens Marketing Agreement checklist group compost teas with other non-synthetic crop treatments and ask questions about their use. These questions include whether they were applied to the consumed part of the crop and whether they tested negative for *Salmonella* and *E. coli* O157:H7. The Primus ranch audit asks if non-synthetic crop treatments were applied at least 45 days before harvest. The Leafy Greens Marketing Agreement checklist asks the same question, unless the material was "...produced using a validated process for pathogen control."

## Topics

- Goals
- Why should I care?
- General considerations
- **GAPs**
  - Animals
  - Manure and compost
  - **Other animal byproducts**
  - Biosolids
  - Site selection
- Case study
- Summary



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### **PPT 5-53: Topics**

Now I'm going to say a few words about animal byproducts other than manure and its derivatives.

## Other Animal Byproducts

- E.g., bloodmeal, bonemeal, feathermeal, fish emulsion
- Little information
- Process check
- Watch for contamination with manure



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### **PPT 5-54: Other Animal Byproducts**

Some soil amendments, other than manures, also come from animals. These include feathermeal, bonemeal, bloodmeal and fish emulsion. There is little information on their ability to transmit pathogens to crops, although *Salmonella* has been found in raw bloodmeal intended for animal feed (Calixto et al., 2002). Growers may want to check how these products have been processed. As with other materials that are ready to be used in the field, contamination of these products with manure should be avoided.

The Primus ranch audit and the Leafy Greens Marketing Agreement checklist group these, along with compost tea, as non-synthetic crop treatments. Some questions related to these were mentioned in relation to compost tea.

## Topics

- Goals
- Why should I care?
- General considerations
- **GAPs**
  - Animals
  - Manure and compost
  - Other animal byproducts
  - **Biosolids**
  - Site selection
- Case study
- Summary

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### **PPT 5-55: Topics**

Now we're going to talk about biosolids.

## Biosolids

- Use of "sewage sludge generated during the treatment of domestic sewage in a treatment works" is regulated by federal law (40CFR503).

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### **PPT 5-56: Biosolids**

As defined by federal regulation, biosolids are "sewage sludge generated during the treatment of domestic sewage in a treatment works."

## Biosolids

- Regulated under NC law (15A NCAC 02T), too, as "residuals"
- "...solid, semisolid, or liquid waste...generated from a wastewater treatment facility, water supply treatment facility or air pollution control facility permitted under the authority of the Commission"

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### **PPT 5-57: Biosolids (cont'd)**

North Carolina law uses the term "residuals" instead of "biosolids." Residuals are defined broadly as "...any solid, semisolid, or liquid waste, other than effluent or residues from agricultural products and processing, generated from a wastewater treatment facility, water supply treatment facility or air pollution control facility permitted under the authority of the [Environmental Management] Commission" (15A NCAC 02T).

## Biosolids

- Class A
  - Can be sold directly to public
- Class B
  - Applied by producer, under permit that states how long before harvest it must be applied

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### **PPT 5-58: Biosolids (cont'd)**

For our purposes, biosolids are what come out of sewage plants. Legally, Class A and B biosolids, as defined under North Carolina law, can be used in agricultural fields. Class A biosolids have been processed according to a documented method and subjected to pathogen-related quality-control standards. They are the only ones that can be sold directly to the public. Class B biosolids can be applied to the land by those who have a permit to produce them. North Carolina permit restrictions state that Class B biosolids must be applied at least 30 days, 14 months, 20 months or 38 months before harvest, depending on the amount of contact between the eaten part of the crop and the soil, and how long the biosolids are left on the soil surface before they are incorporated. There are additional environmental requirements about where Class A and B residuals can be applied. (15A NCAC 02T)

## Biosolid Concerns

- Pharmaceuticals are sometimes present.
- There is little information about uptake by plants, but it has been shown in manure-amended soil.

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### **PPT 5-59: Biosolid Concerns**

One concern related to the use of biosolids and manures is the presence of pharmaceuticals such as antibiotics. At present, information is lacking about the uptake of human antibiotics from soil amended with biosolids, but research has shown that plants can take up some antibiotics from some animal manures (Dolliver et al., 2007; Kumar, et al., 2005). Antibiotic resistance and antibiotic allergies are potential concerns (Kumar et al., 2005), and more research may be needed in this area.

## Biosolid Concerns

- Allowed heavy metal concentrations are regulated by law.
- Levels of heavy metals are typically low in domestic biosolids.

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### **PPT 5-60: Biosolid Concerns (cont'd)**

The possible presence of heavy metals in biosolids has also been an area of question. North Carolina law regulates how high heavy metal concentrations can be for both Class A and Class B biosolids. Levels of heavy metals in domestic biosolids are typically low, and with the exception of cadmium, heavy metals would be expected to harm plant growth before reaching levels that would harm humans.

## Biosolids

- USDA audit asks:
  - Is composted manure “properly treated, composted, or exposed to environmental conditions that would lower the expected level of expected pathogen”?
  - Are “[a]nalysis reports... available”?

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### PPT 5-61: Biosolids

The USDA audit groups biosolids with compost, asking if they were “...properly treated, composted or exposed to environmental conditions that would lower the expected level of expected pathogens,” and asking for analysis reports.

## Biosolids

- Primus checklist asks:
  - “Are biosolids incorporated...prior to planting or bud burst...?”
  - Is there documentation of what was used, when and where?
  - “Is there a Certificate(s) of Analysis...certifying compliance with prevailing national/local standards and guidelines?”

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### PPT 5-62: Biosolids

The Primus ranch audit questions whether biosolids are allowed in the particular case and whether they are incorporated before planting or tree fruit bud break. Documentation of quality control is required.

## Biosolids

- LGMA checklist:
  - Biosolids not allowed under LGMA (within one year)
- National Organic Program:
  - Not allowed

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### PPT 5-63: Biosolids

The Leafy Greens Marketing Agreement checklist asks if biosolids have “been applied in the last 1 year.” They’re not allowed by National Organic Program standards.

## Topics

- Goals
- Why should I care?
- General considerations
- **GAPs**
  - Animals
  - Manure and compost
  - Other animal byproducts
  - Biosolids
  - **Site selection**
- Case study
- Summary



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### **PPT 5-64: Topics**

Finally, we're going to talk about site selection.

## Site Selection

- Has the site been exposed to activities or conditions in the past that might have resulted in contamination?
- Is adjacent land being used for purposes that might result in contamination of crop land?



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### **PPT 5-65: Site Selection**

In evaluating a site, the grower should consider the past uses of the particular site as well as current and future possible uses of adjacent land.

## Site Selection

- Land use history
  - Livestock or manure
  - Flooding
  - Hazardous chemicals
- Current proximity to livestock operations, cull piles, refuse dumps and debris



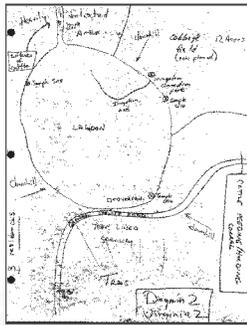
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### **PPT 5-66: Site Selection (cont'd)**

Potential site contaminants include microbial hazards such as manure and flooding, and non-microbial hazards such as hazardous chemicals.

Potential threats from nearby locations include livestock operations, cull piles, refuse dumps and debris. Even if some of these factors do not pose a threat by themselves, they may attract animals.

## Site Selection



Farm layout



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Slide modified from D. Sanders presentation

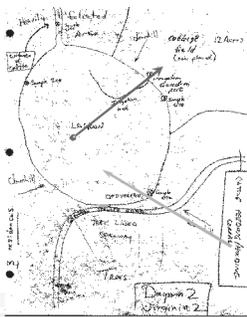
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### PPT 5-67: Site Selection

Here we have a concentrated livestock area, a pond and a cabbage field.

## Site Selection



- Farm diagram
- Feedlot drains into irrigation pond

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Slide modified from D. Sanders presentation

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### PPT 5-68: Site Selection

Runoff from the livestock area enters the pond. The diagram suggests that the pond is used for irrigation. Even if it were not, contaminated water would likely end up in the cabbage field if the pond overflowed. Growers may want to obtain a map to help evaluate whether drainage from other areas into water sources or produce fields may be a problem.

## Site Selection

- Soil can be tested for fecal bacteria, heavy metals or chemical contamination.
- Fecal coliforms or *E. coli* are often used as indicators of contamination by manure or sewage.

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### PPT 5-69: Site Selection

Soil can be tested for fecal bacteria, heavy metals, or chemical contamination. Fecal coliforms or *E. coli* are often used as indicators of contamination by manure or sewage. (Research has shown, however, that *Salmonella* decline may not mirror that of *E. coli* [Eamens et al., 2006].)

## Site Selection

- USDA, Primus and LGMA questions are related to site factors.
- Primus ranch audit asks for results of soil tests when land was used for non - agricultural purposes or has been flooded.

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### **PPT 5-70: Site Selection**

The USDA audit, Primus ranch audit and LGMA checklist all inquire about site factors.

## Topics

- Goals
- Why should I care?
- General considerations
- GAPs
  - Animals
  - Manure and compost
  - Other animal byproducts
  - Biosolids
  - Site selection
- **Case study**
- Summary

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### **PPT 5-71: Topics**

*Distribute HO 3-3*

#### **Activity**

Now, we're going to do an activity. First, I'm going to have you divide into groups of (*you choose*). Then, read over the information you're going to be given about an imaginary farm and discuss the two questions with your group. After 10 (*or you choose*) minutes, you'll share some of your answers with the larger group.

### **PPT 5-71 (continued)**

#### **Module 5: Case Study**

The owners of Muscadine Acres Produce Farm grow a variety of vegetables and fruits. They also have two broiler houses. The farm is located in an area of the county where a lot of people have cattle. Most of the farm's produce is sold from farmers markets, but they sell wholesale to one grocery store chain. They make compost from their chicken litter and use it to fertilize their vegetable fields. They use uncomposted litter in their orchard and vineyard. Irrigation is through a drip system on vegetables and in the vineyard, and overhead in the orchard. The water comes from ponds scattered over the farm.

What do you need to know to decide how well they are following GAPs?

*(Using case study sheet, go over their answers, and suggest additional answers if they've missed some.)*

## Topics

- Goals
- Why should I care?
- General considerations
- GAPs
  - Animals
  - Manure and compost
  - Other animal byproducts
  - Biosolids
  - Site selection
- Case study
- **Summary**

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### PPT 5-72: Topics

#### Summary

Review of topics discussed.

## Summary

- GAPs are relevant to public health, farm and industry financials and audits.
- Pathogens often come from animal or human waste.
- Crops differ in their risk of transmitting pathogens.

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### PPT 5-73: Summary

GAPs are important to public health. Their use may prevent sales losses and lawsuits due to fresh produce safety problems, and they may help growers pass audits demanded by buyers. If growers can prevent further problems, more government regulation might be avoided.

Animals and animal byproducts are potential sources of human pathogens. Growers can take measures to reduce the risk that produce will be contaminated.

When working with animals or animal-derived materials, growers should consider the nature of the crop. Does the eaten part have virtually no contact with the soil or soil amendment? Is it near or does it rest on the soil, or is it a root crop? Is it generally cooked before being eaten?

### PPT 5-74: Summary (cont'd)

Growers can reduce the risk of contamination by keeping domestic animals and runoff from their manure out of the field during the growing season and out of water sources, and by taking measures to restrict the access of wild animals, when there is evidence of large populations.

Applying manure earlier and aging or composting it are ways to reduce the risk associated with pathogens in manure. Composting, if it is done according to guidelines that optimize the kill of pathogens, is preferable to aging. Pathogen numbers in slurry decline faster than in solid manure in some cases, but caution should still be used.

## Summary

- Keep animals and run-off from their waste away from crops and irrigation water.
- Applying manure earlier, aging and composting are ways to reduce risk.

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## Summary

- Take much caution if considering using manure or compost tea.
- Consider the manner used to process bone and bloodmeal.

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### **PPT 5-75: Summary (cont'd)**

The use of manure tea is not recommended unless it can be heat-treated to kill pathogens. The safety of compost tea depends on having properly produced compost or treating it, as with heat. Testing teas before applying them to crops is recommended, if there is any doubt about whether pathogens have been killed. With any treated manure product, it is important to prevent recontamination.

There is not a great deal of information on the potential contamination of crops by non-feces derived amendments, or by materials that are animal products but are not based on manure.

## Summary

- Biosolid production and use are regulated by federal and state law.
- Pharmaceutical and heavy metal contamination are potential concerns.

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### **PPT 5-76: Summary (cont'd)**

Standards for treatment of Class A biosolids are defined by federal law, and they can be purchased by individuals and applied. Class B biosolids are applied by their producer, under permit conditions defined by the N.C. Department of Environment and Natural Resources (DENR). It is not clear to what extent plants can absorb pharmaceuticals, but it appears possible, based on research performed with manure. Heavy metal levels in biosolids are regulated by law.

## Summary

- Consider what has happened on a considered site in the past and what is going on around the site.

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### **PPT 5-77: Summary (cont'd)**

Finally, consider how the site has been used in the past, what is around it, and whether contamination might be present now or in the future.

**Thank You!**

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**PPT 5-78: Thank You!**

Thank you for coming today. Are there any questions before we take a post-test?

*Distribute HO 4-2*

**Activity:** Post-test

Please complete the evaluation before you leave and [*give it to me/leave it on the table/etc.*].

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**Module 5: Animals, Animal Byproducts, Biosolids, and Site Selection**

**Pre-Test/Post-Test**

ID Number/Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. Give three reasons why GAPs are important.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- 2. Only certain strains of *E. coli* are harmful to humans. .... True or False
- 3. Manure can be safely applied to crops until 20 days before harvest. .... True or False
- 4. Pathogens always die off more quickly when manure is incorporated into the soil than when it is spread on the surface..... True or False
- 5. Composting and aging manure result in equally fast pathogen death..... True or False
- 6. Pathogens have been found to die off more quickly in solid slurry than in solid manure. .... True or False
- 7. Biosolid use on crops is illegal in North Carolina. .... True or False
- 8. Application of manure tea is not recommended at any time. .... True or False

**Module 5: Animals, Animal Byproducts, Biosolids, and Site Selection (Answers)**

1. Give three reasons why GAPs are important.
  - a. public health
  - b. protect sales (self and industry)
  - c. avoid lawsuits
  - d. pass audits
  - e. avoid regulations
  
2. Only certain strains of *E. coli* are harmful to humans. ....**True** or False
  
3. Manure can be safely applied to crops until 20 days before harvest. ....True or **False**
  
4. Pathogens always die off more quickly when manure is incorporated into the soil than when it is spread on the surface.....True or **False**
  
5. Composting and aging manure result in equally fast pathogen death.....**True** or False
  
6. Pathogens have been found to die off more quickly in solid slurry than in solid manure. ....True or **False**
  
7. Biosolid use on crops is illegal in North Carolina. ....True or **False**
  
8. Application of manure tea is not recommended at any time. ....**True** or False



## **Module 5: Animals, Animal Byproducts, Biosolids, and Site Selection**

### **Case Study Answers**

The owners of Muscadine Acres Produce Farm grow a variety of vegetables and fruits. They also have two broiler houses. The farm is located in an area of the county where a lot of people have cattle. Most of the farm's produce is sold from farmers markets, but the owners sell wholesale to one grocery store chain. They make compost from their chicken litter and use it to fertilize their vegetable fields. They use uncomposted litter in their orchard and vineyard. Irrigation is through a drip system on vegetables and in the vineyard and overhead in the orchard. The water comes from ponds scattered over the farm.

What do you need to know to decide how well they are following GAPs?

- ♦ Is compost production monitored to see that it's produced in a way that kills pathogens?
- ♦ Are manure and unfinished compost stored where they won't run off onto produce fields?
- ♦ Is uncomposted litter applied while trees are dormant? (Some audits would find even dormant-season application unacceptable.)
- ♦ Are land conditions such that runoff from litter in broiler houses and on the land surface is likely to go into the ponds (especially any used for orchard irrigation)?
- ♦ Is equipment cleaned between use in litter/unfinished compost and finished compost?
- ♦ Is finished compost stored where it won't be re-contaminated by animals, runoff, etc.?
- ♦ How close are produce fields to neighbors' cattle?

Without knowing any other information, what do you think might be some potential sources of produce contamination?

- ♦ Improperly composted litter
- ♦ Runoff from litter or unfinished compost (in storage or in fields) onto fields with produce and into irrigation ponds (especially ponds used to irrigate orchard)
- ♦ Runoff from neighboring cattle grazing areas

