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Bulletin

Guidelines for Land Application of Non-Traditional Organic Wastes (Food Processing By-Products and Municipal Yard Wastes) on Farmlands in New Jersey

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Summary

This is a guide to planning and implementing on-farm management practices for land application of non-traditional organic wastes (food processing by-products and yard wastes) as fertilizers and soil conditioners on farmlands in New Jersey.

- A detailed site management and operation plan should be in place before non-traditional organic wastes are used in farm operations. (see section 1)

- Non-traditional organic wastes applied to farmlands must meet all federal, state, and local regulations. (see section 2)

- As traditional organic wastes such as manure and crop residues, the chemical and physical characteristics of non-traditional organic wastes are very variable which might affect crop production and the environment. Therefore, waste analyses should be obtained when planning to apply non-traditional organic wastes. Generally, field values for N availability from the wastes are lower than laboratory values for N availability. (see section 3)

- Suitable soils, as specified by NJDEP or other federal or state regulatory agencies, should be selected for land application of non-traditional organic wastes. The most suitable soils are those with few limitations that restrict incorporation of the wastes and/or prevent the on-site use of nutrients in the organic waste (e.g., soil wetness, slope, and texture). Food processing by-products and municipal yard wastes should not be applied near surface water body (a distance of at least 33 feet for food processing by-products and 100 feet for grass clippings required by regulatory agency), on soil with water on the surface, on soils having bedrock or water tables at less than a 24 inch depth, on slopes greater than 12%, and on flooded, frozen or snow covered soils. (see section 4)

- Appropriate crops on fields where non-traditional organic wastes are applied include field crops (including legumes), ornamental nursery stock, and to a lesser degree vegetable and fruit crops. Suitable crops and cropping patterns depend on the time of the year the wastes become available, how the wastes are processed, and if the wastes are used as an N fertilizer or soil conditioner. (see section 5)

- Application rates of non-traditional organic wastes should be selected in a manner to optimize crop growth and at the same time minimize environmental impacts. The actual application rate is calculated based on the most limiting characteristic. The limiting characteristic can be a waste characteristic (e.g., N, pH, moisture, oils and fats) or a soil property (e.g., P, pH, organic matter). (see section 6)

- The organic wastes should be incorporated evenly within the top 4 to 6 inches of soil. Incorporation helps degrade the wastes, reduce odors and prevent the wind from blowing light organic wastes (e.g., leaves). In addition, incorporating the wastes with soil reduces run-off of organic wastes and volatilization of ammonia from organic wastes used as N fertilizer. However, incorporation might negatively affect crop residue cover which may increase soil erosion. (see section 7)

- Annual soil testing is recommended to account for residual nutrients in the soil and help determine crop needs and nutrient management decisions. The Pre-sidedress soil nitrate test (PSNT) is an in-season test that should be used to monitor the soil for plant available N from organic wastes in fields with corn or certain vegetable crops. (see section 8.1)

- A current resource management system (RMS, formerly farm conservation plan) developed by the United States Department of Agriculture - Natural Resource and Conservation Service (NRCS) or third party vendors like Certified Crop Advisors and approved by the local Soil Conservation District (SCD) should be fully implemented and consulted before application of non-traditional organic wastes. (see section 8.2)

1. Introduction

These guidelines present initial steps and on-farm management practices for *land application*[1] of *non-traditional organic wastes* as *fertilizers* and *soil conditioners* on farmlands in New Jersey. The objective of these guidelines is to optimize nutrient uptake by crops and improve soil fertility and quality, while minimizing environmental impacts.

Non-traditional organic wastes include municipal *yard wastes* and *food processing by-products*. Municipal yard wastes consist of leaves, grass clippings, woody brush and tree trimmings that are generated by residents, businesses and institutions and are collected by municipalities and landscapers. Food processing by-products include *food processing vegetative wastes* and *food processing residuals* (sludge). Food processing vegetative wastes include peels, skins, and seeds left over from trimming, reject sorting, cleaning, pressing, cooking, and other food processing operations. Food processing residuals are solid materials removed during wastewater treatment in a food processing plant. Food processing residuals are separate from (and do not include) sanitary input. While these guidelines provide some information about food processing residuals, the focus is on food processing vegetative wastes and municipal leaves and grass clippings. Municipal woody brush and tree trimmings used as a wood chip *mulch* after shredding are not covered.

Non-traditional organic wastes can be used as a soil conditioner and/or as a fertilizer (mainly N fertilizer). A soil conditioner contributes to organic matter content of the soil, soil structure and aggregation, and soil moisture retention. Non-traditional wastes with high C/N ratios (carbon/nitrogen ratios, see section 3) and low amounts of N are initially used for soil conditioning and to a lesser degree for their nutrient content. Non-traditional organic wastes with low C/N ratios and high N contents are mainly used as N fertilizer and serve only secondarily as an organic soil conditioner.

In most cases, non-traditional organic wastes are not processed before being land applied. Therefore, a variety of potential problems can be associated with their use, including release of *odors*, attraction of flies, contamination with trash, presence of viable weed seeds, pesticide residues, plant *pathogens* and animal pathogens (e.g., from pet droppings). Although there are potential problems with the use of unprocessed, non-traditional, organic wastes, many can be avoided with prior knowledge of the waste characteristics (waste analysis and visual inspection), proper siting criteria (soil suitability and avoiding environmentally sensitive areas), and timely application and incorporation. The potential problems can also be reduced if the wastes are processed, for example, by composting. These guidelines do not cover composted products.

When land applying non-traditional organic wastes, effects on the management of farm operations must be considered. Careful planning before application of non-traditional organic wastes to farmlands is essential to avoid environmental degradation that can occur due to improper application and management. The farmer should be knowledgeable about the entire land application system to understand how the application affects his/her agricultural operation (soil fertility, use of herbicides, crop rotation, tillage, compaction, soil erosion, etc.).

These guidelines do not establish legal requirements but rather provide a methodology for an environmentally sound and economic use of non-traditional organic wastes in an agricultural production system if there is a benefit to the crop to be grown. They are also not an endorsement of land application of non-traditional organic wastes. As with other fertilizers and soil conditioners, the individual farmer should make the decision on

(Footnotes)
[1] Glossary terms are marked in *italics* when mentioned in the document the first time (see Appendix 4).

economics and other criteria specific to each situation. Information to aid in making this decision may be obtained from Rutgers Cooperative Extension (RCE) personnel and from state officials (see Appendix 1).

Information in these guidelines is based on information and interpretation of past research regarding land application of crop residuals, manure, and non-traditional organic wastes available in the year 2002. The interpretation and numerical values may change due to results of further research. These guidelines will be updated periodically to reflect future findings (e.g., for herbicides in yard wastes, for nutrient availability) and changes in regulations or standards developed by United States Environmental Protection Agency (USEPA), New Jersey Department of Environmental Protection (NJDEP), and/or other federal and state agencies.

Additional information about land application of non-traditional organic wastes can be found in Brandt and Martin (1994), USDA Soil Conservation Service (1996) and Nagle et al. (1997).

2. Regulations and Permits

Land application of food processing by-products and yard wastes on farmlands are regulated by the NJDEP. The Division of Water Quality, Bureau of Pretreatment and Residuals is generally responsible for land application of food processing by-products that are part of a *NJPDES permit* and the Division for Solid and Hazardous Waste, Bureau of Resource Recovery and Technical Programs for land application of municipal yard wastes and food processing by-products that are not part of a NJPDES permit. If it is not clear, if the food-processing by-product is handled by the Division of Water Quality, Bureau of Pretreatment and Residuals or the Division for Solid and Hazardous Waste, Bureau of Resource Recovery and Technical Programs, the programs should be contacted to determine the specifics of your case. The regulations and permit requirements are different for each waste type. The following provides a summary of the regulations and permit requirements for land application of non-traditional organic wastes in New Jersey. However, it is highly recommended that the actual regulations for each waste type be carefully reviewed by the parties involved and that NJDEP be contacted when considering using non-traditional organic wastes.

2.1 Food Processing By-Products

When the Division of Water Quality, Bureau of Pretreatment and Residuals is responsible for the food processing by-product, state legal requirements for the land application of food processing by-products can be found in N.J.A.C. 7:14A-20 and N.J.A.C. 7:14C. The Bureau of Pretreatment and Residuals has established a *general permit* for food processing vegetative wastes and food processing residuals. The food processor, not the farmer, applies for a permit for the land application of these food processing by-products. After the food processor submits the application, the Bureau of Pretreatment and Residuals determines if a food processor can be covered by the conditions of the general permit. A general permit is not required for each land application site, however, the food processor is responsible for the proper use of these food processing by-products delivered to each site. If the Bureau of Pretreatment and Residuals determines a particular food-processing vegetative waste or food processing residual has a pathogen, *vector attraction* or odor issue, the food processor may need to submit an application for an *individual permit*. Generally, food processing non-vegetative wastes are not covered by the general permit.

Some of the information required for the application for a general permit includes:

1. Source and quality of the food processing by-products and information about the food processing facility itself. A dated analysis needs to include at minimum total solids (moisture content), pH, nutrients and certain heavy metals. In some cases, additional analyses are required.

2. Verification that the local municipality and the affected sewage authority were notified.

Application forms can be obtained from the Bureau of Pretreatment and Residuals or via the Internet at http://www.state.nj.us/dep/dwq.

Major provisions required by the general permit are:

- Total solids, pH and nutrients need to be determined quarterly for food processing vegetative wastes and monthly for food processing residuals by a New Jersey certified laboratory.

- The food processor needs to retain the monitoring results for food processing vegetative wastes for at least five years while the monitoring results for food processing residuals need to be submitted to NJDEP, Division of Water Quality, Division of Pretreatment and Residuals on pre-printed monitoring report forms supplied by NJDEP.

- The food processor needs to collect the following information for each site before application and to keep this information for at least five years: 1) User's name, address and phone number, 2) county, municipality, street address, tax lot and block number, 3) a copy of the county soil survey map denoting the total acreage and boundaries of the land application site, 4) a property owner's certification by *user site* property owner, and 5) a copy of an approved *resource management system (RMS)*.

- The application rate should not exceed the annual N crop requirement (see Rutgers Production Recommendations for New Jersey Fields Crops) or as otherwise recommended by Natural Resources and Conservation Service (NRCS).

- Food processing by-products should not be applied within 33 feet from "*waters of the State*", during precipitation, on saturated ground, on land with more than 12% slope, or on flooded, frozen, or snow covered ground.

- Some additional requirements regarding loading rates, prevention of run-off and storage in transport trucks on site are given for liquid food processing by-products.

- Food processing by-products need to be incorporated within 48 hours unless the slope of the land is less than 5% or crop residues or a vegetative land cover at least 75% of the land to prevent run-off.

- There are requirements concerning stockpiling of dewatered, food processing by-products.

- A crop needs to be grown on fallow fields immediately after application.

In certain cases, when the Division for Solid and Hazardous Waste, Bureau of Resource Recovery and Technical Programs is responsible, the application of the food-processing by-product might be considered for use in a beneficial use project (N.J.A.C. 7:26-1.7(g)5). An application for a certification needs to include detailed information about the food-processing by-product, the site where the material is to be used, a description of the measures to be taken during handling and transportation of the food-processing by-product to minimize environmental and human health impacts, and evidence that the material provides a beneficial use. For further details see N.J.A.C. 7:26-1.7(g)5 or contact the Bureau of Resource Recovery and Technical Programs.

A "Food Processing By-Product Land Application Agricultural Management Practice" rule (N.J.A.C. 2:76-2.A.4) was enacted by the New Jersey Department of Agriculture to provide Right to Farm protections for eligible farmers using food processing by-products as a soil amendment. For the most part, this rule requires the same practices as a NJDEP general permit under the NJDEP, Division of Water Quality, Bureau of Pretreatment and Residuals. Food processing by-products that require an individual permit might not be covered by this rule.

2.2 Municipal Yard Wastes

State legal requirements for handling municipal yard wastes can be found in N.J.A.C. 7:26A. Since leaves are less prone to odors than grass clippings, legal and permit requirements for land application of leaves and grass clippings differ.

- Municipal leaves

Land application of leaves is exempted from solid waste permitting (N.J.A.C. 7:26A 1.4(a)12), if

1. the land application site is deemed actively devoted to agricultural or horticultural use, as defined in the Farmland Assessment Act of 1964, N.J.S.A. 54:4-23.5, and
2. the leaves are delivered unbagged, and
3. the leaves are spread onto the field in a thin layer no higher than 6 inches within 7 days of delivery, and,
4. the layered leaves are incorporated into the soil no later than the next tillage season.

However, before applying leaves, the farmer must notify NJDEP, Division for Solid and Hazardous Waste, Bureau of Resource Recovery and Technical Programs, the host municipality and the host county where it is applied prior to commencing operation. Other requirements can be found in N.J.A.C. 7.26A 1.4(b).

- Municipal grass clippings

Generally, application of grass clippings is less common in New Jersey than the application of leaves. The farmer must request permission from the Bureau of Resource Recovery and Technical Programs to conduct a *Research, Development & Demonstration (RD&D) project.* The application must include:

1. The location of the RD&D project, including a site plan map and a plot plan of the area(s) intended for grass clippings application.

2. A description of the proposed project:

   - Identification of the proposed source(s) of the grass clippings
   - A detailed description of the use of grass clippings such as the grass clipping application rate, type of crop(s) to be grown, and timing of application relative to planting.
   - The application rate should be based on a *Nutrient Management Plan* approved by the Soil Conservation District. A copy of the approval should be provided.
   - A description of the operations such as schedule of grass clippings receipt and application, and activities following the application.
   - Description of the equipment to be used for handling and spreading the grass clippings.

3. Duration of project including start and end dates.

4. Outline of the need of the project and measure that will be used to determine success.

5. Description of what information and improved operation this demonstration will provide.

6. Description of the improved environmental effectiveness and/or efficiency of operations that will be demonstrated.

7. A description of the sampling and analytical plan of the material and process being demonstrated and the potential air, water, and soil emissions or discharges. As a minimum, incoming grass clippings and soils receiving grass clippings should be analyzed for moisture, pH, and on a dry-weight basis N (total, nitrite/nitrate and ammonium), P, K, copper, magnesium, manganese, and zinc.

8. A description of the *quality assurance/quality control plan* for the overall demonstration and sampling and analytical plan.

9. Written documentation that the RD&D project is included by administrative action within the district solid waste management plan for the county or district where the project is located.

10. A description on how the operation will comply, or will not comply, with the following criteria:

    - The land application site deemed actively devoted to agricultural or horticultural use, as defined in the Farmland Assessment Act of 1964, N.J.S.A. 54:4-23.5, and
    - The site has good road access and controls to prevent unauthorized persons from entering after operational hours.
    - The receiving area shall be no closer than 1,000 feet of any property line of sensitive receptor (area of human use or occupancy).
    - The grass clippings shall be delivered unbagged and free from debris.
    - The operator shall make a reasonable effort to spread grass clippings at the loading rate specified in the Nutrient Management Plan and incorporate the clippings into the soil on the day of receipt. In no case should the clippings be staged more than 24 hours.
    - The location of the grass clippings application shall not be within the 100-year floodplain zone or within 100 feet of a surface water body; nor shall the operation conflict with the objectives of any applicable Federal, State or local land use and environmental requirements.
    - No application within 50 feet of the property line, within 150 feet of the property line of the nearest sensitive receptor, and within 250 feet from any occupied structure.
    - The operator shall maintain a written log.

More detailed information about who is eligible to conduct a grass clippings demonstration project and what performance standards apply during the demonstration project can be obtained from the Bureau of Resource Recovery and Technical Programs.

3. Characterization of Non-Traditional Organic Wastes

Characteristics of non-traditional organic wastes must be known to determine application rates and to evaluate how the application might affect crop production and the environment. Even though each waste is unique, for ease of comprehension, we will separate the non-traditional organic wastes into two categories depending on whether they are used mainly as a N fertilizer or as a soil conditioner.

Non-traditional organic wastes that are high in N and have a low C/N ratio are mainly used for their N content and only secondarily for their soil conditioning properties. These organic wastes will be categorized as N fertilizers. Non-traditional wastes that are low in N and have a high C/N ratio are mainly used for their soil conditioning properties and only to a lesser degree for their N content. These organic wastes will be categorized as soil conditioners. As a general rule, wastes with C/N ratios below 20 are used as N fertilizers, while wastes with a C/N ratio above 30 are used as soil conditioners. Wastes with C/N ratios between 20 and 30 can fall in either category. Both N fertilizers and soil conditioners contain nutrients other than N which may limit the application rates.

Due to the high N content, organic wastes used as N fertilizers tend to be more prone to N leaching than organic wastes used as soil conditioners. Therefore, due to the higher N application rate of organic wastes as N fertilizers, they may affect water quality more than soil conditioners.

Non-traditional wastes used as N fertilizers may also cause more odor problems than organic wastes used as soil conditioners. The high N content accompanied by a high degradability similar to the high N content and the high degradability of manures increase the demand for oxygen. With a lack of oxygen, organic wastes can become *anaerobic*. Anaerobic conditions are accompanied by unpleasant odors.

A large portion of nitrogen applied with non-traditional organic wastes is not immediately available for plant uptake. Available N includes inorganic N (ammonium N and *nitrate N*) and the portion of organic N that mineralizes during the growing season. *N availability* is the percentage of the total N of the organic waste that becomes available in a growing season. Depending on waste type, soil type and environmental conditions, N availability can vary from N *immobilization* to more than 50% N availability. Potential N availability can be obtained from laboratory *N mineralization rate* studies. These studies give an indication to what degree the organic wastes release or immobilize N. Field conditions and management practices such as tillage, *soil texture* and moisture often result in lower field mineralization rates compared to laboratory mineralization rates. Generally, the N availability determined in the field is lower than the N availability determined in the laboratory.

The availability of K applied with organic wastes are almost 100% in one growing season while the availability of P lies between the availability of N and K.

Waste type and source, season and handling method affect the characteristics of non-traditional organic wastes. As with other organic amendments such as manure and sewage sludge (biosolids), the characteristics of non-traditional organic wastes are extremely variable and need to be considered when using non-traditional organic wastes.

Due to variability, waste analyses are very important. The waste analysis should be completed by a *certified laboratory* and be recorded in *dry weight basis* units. According to the regulations, the *generator* is only responsible for the analysis of food processing by-products. However, the farmer can also request an analysis from the generator of municipal yard wastes.

The following sections will summarize waste characteristics that should be analyzed when considering and/or applying non-traditional organic wastes. Characteristics of organic wastes found in New Jersey will also be presented.

3.1 Food Processing By-Products

Food processing by-products include food processing vegetative wastes and food processing residuals. Food processing vegetative wastes are peels, skins, and seeds left from trimming, reject sorting, cleaning, pressing, cooking and other food processing operations. Food processing residuals are the solid material removed during wastewater treatment. They are sludges high in solids that are separate from and do not include sanitary input.

To apply for a general permit for food processing by-products, a dated analysis of total solids (moisture content), pH, nutrients, and certain heavy metals is required (see section 2). Additional analyses are required on a case-by-case basis and depend on the waste type. Even if not required, the initial analysis of additional characteristics might be advisable because they may limit application timing and rates. Additional parameters to be tested may include C/N ratio, *calcium carbonate equivalent* (CCE), additional heavy metals, synthetic organics including pesticide residuals, soluble salts, and fats and oils. Heavy metals and synthetic organics in food processing by-products are usually found in low concentrations. However, elevated levels of certain heavy metals and synthetic organics can occur. If help is needed to determine which additional analysis should be obtained, contact your local Rutgers Cooperative Extension (RCE) personnel (see Appendix 1).

The general permit for land application requires quarterly monitoring for food processing vegetative wastes and monthly monitoring for food processing residuals. These analyses include, minimum, total solids, pH, N (*total Kjeldahl N*, ammonium N, nitrate N), P, K. Daily fluctuations in processing as well as storage patterns of the generator can change the composition of the organic waste. Therefore, in order to obtain a representative waste characterization, RCE recommends that certain food processing by-products be analyzed more frequently. Depending on the initial analysis monitoring of additional parameters than the required may also be advisable. For food processing by-products that are used as N fertilizer it is recommended that a total solids and a N analysis (total Kjeldahl N, ammonium N) be conducted prior to land application to better adjust the application rate. However, these data are only useful if the analyses can be provided shortly after sample submission.

Table 1 lists chemical and physical characteristics of select non-traditional organic wastes sampled in New Jersey. A wide range of pH, moisture contents, and nutrients were found in these organic wastes. The pH ranged from acidic to neutral (3.1-7.0) with cranberry skins and seeds having the lowest pH. Wastes with above or below soil pH may change the soil pH which can eventually affect crop growth. Food-processing by-products were mainly water (60.7%-91.0%). The C/N ratios of the waste samples ranged from a low of 7:1 to a high of 52:1.

TABLE 1
Chemical and physical characteristics of selected food processing by-products from New Jersey

Waste Type	pH	Cond.	Moisture	NH_4–N	NO_3–N	TKN	Total N	K	P	C/N
		mmhos/cm	%	% dry wt basis						
Food Processing Vegetative Wastes										
coffee grinds	5.1	0.28	61.2	ND	ND	1.64	1.64	0.04	0.005	32
cranberry skins & rice hulls, company A	3.4	0.87	60.7	0.01	0.001	1.07	1.07	0.13	0.10	52
cranberry skins & rice hulls, company B	3.1	0.32	53.3	ND	ND	1.15	1.15	0.07	0.13	44
spinach, carrots, May 1999	5.1	3.68	89.9	0.18	0.02	7.04	7.06	1.82	0.53	7
string beans, green peppers, Aug. 1998	3.9	3.00	91.0	0.02	0.03	2.81	2.84	0.74	0.55	14
string beans, green peppers, lima beans, Aug. 1999	3.9	4.43	86.2	0.13	ND	3.69	3.69	0.99	0.49	11
tomato skins and seeds	4.2	7.60	85.6	0.05	0.002	1.74	1.74	2.03	0.44	31
Food Processing Residuals										
tomato sauce wastewater sludge	5.4	3.60	71.6	0.02	0.002	1.41	1.41	0.21	0.92	18

Values are means of two samples except string beans and green peppers (1998), tomato sauce wastewater sludge, and tomato skins and seeds, which are single sample values.
ND - Not detected

TABLE 1 (continuing)
Chemical and physical characteristics of selected food processing by-products from New Jersey

Waste Type	Ca	Mg	S	Na	Fe	Al	Mn	Cu	Zn
	% dry wt basis			ppm					
Food Processing Vegetative Wastes									
coffee grinds	0.08	0.01	0.11	200	337	739	48	38	14
cranberry skins & rice hulls, company A	0.07	0.04	0.08	100	243	637	19	11	12
cranberry skins & rice hulls, company B	0.15	0.03	0.10	100	698	1185	26	11	19
spinach, carrots, May 1999	1.46	0.41	0.54	400	863	1165	146	26	136
stringbeans, green peppers, Aug. 1998	1.08	0.23	0.20	400	716	1010	52	14	53
stringbeans, green peppers, lima beans, Aug. 1999	0.67	0.28	0.30	150	181	721	40	21	94
tomato skins and seeds	0.29	0.18	0.18	200	470	745	22	20	27
Food Processing Residuals									
tomato sauce wastewater sludge	2.02	0.23	0.35	1700	18300	21600	941	200	656

Values are means of two samples except stringbeans and green peppers (1998), tomato sauce wastewater sludge, and tomato skins and seeds, which are single sample values.
ND - Not detected

N availability for selected wastes from New Jersey determined in a laboratory study are listed in Table 2. The soil type had an effect on the N availability for some wastes. Among the selected food processing by-products, only coffee grinds immobilized N. The release of N was very low for cranberry skins mixed with rice hulls. Among the food processing by-products, the highest N availability was found for tomato skins and seeds even though the C/N ratio was above 30.

The food processing vegetative wastes, used as N fertilizer, supply in many cases large amounts of K and moderate amounts of P. Tomato skins and seeds are an especially good K source. The tomato wastewater sludge is different from vegetative wastes because it supplies low amounts of K, but large amounts of P. The tomato wastewater sludge is also a good Fe and Ca source due to the additives used during the wastewater treatment process. Characteristics of additional New Jersey non-traditional organic wastes summarizing NJDEP data can be found in Appendix 2. More information about characteristics of non-traditional wastes can be found in Brandt and Martin (1994).

TABLE 2

Nitrogen availability in various food processing by-products and municipal yard wastes in two different soils after 25 weeks of laboratory incubation (USE THE LOWEST VALUE WHEN CALCULATING APPLICATION RATES ACCORDING TO SECTION 6.1)

Treatment	% N availability*	
	Adelphia soil	Sassafras soil
N FERTILIZER USE		
Food Processing Vegetative Wastes		
string beans, green peppers	28 - 31	31 - 32
string beans, green peppers, lima beans	33 - 35	28 - 31
spinach, carrots	16 - 17	19 - 20
tomato skins and seeds	48 - 56	50 - 68
Food Processing Residuals		
tomato sauce wastewater sludge	38 - 41	37 - 49
Municipal Yard Wastes		
grass clippings	37 - 40	52 - 70
SOIL CONDITIONER USE		
Food Processing Vegetative Wastes		
coffee grinds	-14 - -21	-6 - -21
cranberry skins & rice hulls, company A	4	12
cranberry skins & rice hulls, company B	12	2
Municipal Yard Wastes		
leaves	-8	5

Modified after Rogers et al. (2001)

* Percentage of the total N of the organic waste. Negative values indicate immobilization of N in soil.

3.2 Municipal Yard Wastes

Municipal yard wastes include municipal leaves, grass clippings, woody brush and tree trimmings. The most environmentally sound practice for yard wastes is to leave them in the yard. For example, grass clippings left on the lawn recycle nutrients and improve the turf quality. Leaves can be used as mulch in the yard. However, not all homeowners and landscapers manage leaves and grass clippings in the yard, and yard wastes are collected by municipalities and landscapers. Composition of yard wastes depends on a number of factors, including methods of collection, storage practices, and effectiveness of separating foreign materials. Similar to food processing by-products, the variability of the sources of the materials makes it difficult to predict the overall nutrient composition of yard wastes. These guidelines do not address woody brush and tree trimmings, which can be used as mulch.

– Leaves

Municipal leaves applied to farmland at a depth no higher than 6-inches do not require prior analysis or approval from NJDEP, Division of Solid and Hazardous Waste. However, in these guidelines it is suggested that an analysis of nutrients and heavy metals in the leaves is requested from the supplier of the leaves because leaf waste varies significantly because of differences among tree species and sources of the leaves.

Table 3 shows results from a municipal leaf collection study completed in New Jersey (Derr et al., 1995; Heckman and Kluchinski, 1996). Municipally collected leaves have relatively low concentration of N, P, K and a mean C/N ratio of 50:1. These characteristics indicate that leaves are soil conditioners and contribute mostly to soil moisture retention and organic matter content. However, leaves placed in fall provide nutrients for crops grown the following cropping season and provide a source of Ca. Results of a laboratory N mineralization of leaves showed a slight immobilization or mineralization of N (Table 2). Leaves mixed with urban soils have been found to have elevated heavy metal concentrations (see RCE fact sheet FS956, Land Application of Sewage Sludge (Biosolids), #6: Soil Amendments and Heavy Metals). Even though there is only very limited information is available in the literature, pathogens from pet droppings or wild animals could be an issue for leaves.

- Grass clippings

According to NJDEP, Division of Solid and Hazardous Waste, as a minimum, grass clippings delivered to the land application site should be analyzed for moisture, pH, N (total Kjeldahl N, ammonium N and nitrate N), P, K, Cu, Mg, Mn, and Zn (see section 2). In these guidelines, it is recommended that a total solids and an N analysis (total Kjeldahl N, ammonium N) be conducted prior to land application to better adjust the application rate. However, these data are only useful if the analyses are provided shortly after sample submission.

The analysis of fresh grass clippings from a 3-year field study conducted by Rutgers University (Krogmann et al., 2001) shows selected characteristics of grass clippings (Table 4). Grass clippings are a good source of N and K and supply moderate amounts of P. As expected, grass clippings have a high N availability (Table 2).

Although herbicide testing is not part of the mandatory testing, grass clippings may contain residual herbicides. Persistence of residual herbicides and certain herbicides being present at a higher concentration in yard

TABLE 3

Chemical composition of municipal leaves collected in New Jersey (dry weight basis)

	Minimum	Maximum	Mean	
C/N ratio	26.8	71.8	50	
		%		lb/ton
C	36.00	52.00	47	940.0
N	0. 66	1.62	1.00	20.0
P (P_2O_5)	0.02 (0.05)	0.29 (0.66)	0.1 (0.23)	2.0 (4.6)
K (K_2O)	0.09 (0.11)	0.88 (1.06)	0.38 (0.46)	7.6 (9.1)
Ca	0.13	3.04	1.64	32.8
Mg	0.02	0.46	0.24	4.8
S	0.01	0.21	0.11	2.2
		ppm		lb/ton
B	7	72	38	0.076
Fe	46	9800	733	2.922
Al	58	10554	1200	2.400
Mn	19	1845	550	1.100
Zn	22	392	81	0.162
Na	36	325	110	0.220
Cl	68	3995	1264	2.528
Cu	2.8	31.5	9.2	0.0184
Co	0.9	10.9	3.1	0.0062
Cd	0.1	6.8	1.7	0.0034
Pb	3.1	399.9	28.4	0.0568
Ni	1.1	57.9	7.2	0.0144
Cr	0.9	35.1	7.6	0.0152
Ba	4.2	142.0	59.6	0.1192

100 samples (Heckman and Kluchinski, 1996)

wastes at certain times of the year (spring and fall) can be a potential problem when the grass clippings or even composted grass clippings come in contact with sensitive crops such as tomatoes and beans. For example, clopyralid, a broadleaf weed herbicide applied to grass in late spring and late summer, was found to negatively affect certain vegetable crops in soils amended with composted grass clippings containing this compound (Rynk, 2000). As a result, residential uses of clopyralid are discontinued. However, a grass clipping study conducted on three farms in Pennsylvania by the Lancaster County Solid Waste Authority showed that grass clippings from lawns that were treated with herbicides did not pose a problem for corn (Lancaster SWMA, 1991). Therefore, before grass clippings are applied to the soil, surveying the local landscapers about what lawn chemicals have been used and obtaining additional analysis of the grass clipping samples before application is strongly recommended.

Even though only very limited information is available in the literature, pathogens from pet droppings or wild animals could be an issue for grass clippings.

TABLE 4

Selected characteristics of municipal grass clippings.

	Minimum	Maximum	Mean	
pH	6.6	8.3	8.0	
		% wet wt.		
Moisture	34	71	53	
		% dry wt.		lb/ton
TKN	2.34	3.80	3.04	60.8
NH_4-N	0.37	1.14	0.62	12.4
NO_2-NO_3-N	<0.001	0.0041	0.0021	0.042
P (P_2O_5)	0.23	0.56	0.40	8.0 (18.3)
K (K_2O)	1.44	2.32	1.88	37.6 (45.5)
Ca	0.67	1.02	0.85	17.0
Mg	0.28	0.39	0.33	6.6
S	0.30	0.50	0.38	7.6
		ppm dry wt.		lb/ton
Na	500	700	500	1.0
Fe	2,730	8,280	5,190	10.38
Al	1,760	5,710	2,860	5.72
Mn	96	161	128	0.256
Cu	16	55	24	0.048
Zn	58	155	85	0.17

(Krogmann et.al, 2001); 9 samples (2 from 1997, 3 from 1998, and 4 from 1999).

4. Appropriate Soil Types and Field Selection

Knowledge of soil characteristics of the field and criteria to assess the suitability of the site for land application of food processing by-products and municipal yard wastes are essential for the prevention of surface and groundwater contamination from excess nutrients. Information about *soil series* to identify particular farm fields and their land use can be found in the RMS. If soil type and land capabilities are not known for a field, information can be obtained from the U.S. Department of Agriculture (USDA) soil survey, the NRCS (Natural Resource Conservation Service) local soil conservation district and/or the local county extension agent. Actual soil conditions in the field may differ significantly from those suggested in the soil survey; therefore, a qualified soil scientist should visit the site and confirm that the soil survey actually represents the soils.

The most suitable soils for land application of non-traditional wastes are those with few limitations that restrict incorporation of the wastes and/or prevent the use of nutrients in the organic waste (e.g., soil wetness, slope, and texture). Non-traditional wastes should not be applied to soils that have a *land capability classification* of IV, V, VII, or VIII as defined by USDA-NRCS (Soil Conservation Service, 1973).

Fields to avoid land application of food processing by-products and municipal yard wastes include land with steep slopes, near waterways, and with high water tables. They should not be applied on land near surface water body, soil ponded on the surface, on soils having bedrock or water tables at less than a 24 inch depth, on slopes greater than 12%, and on flooded, frozen or snow covered soils. The requirements and recommendations for distances from surface water bodies vary. NJDEP requires 33 feet distance for food processing by-product applications from surface waters and 100 feet for grass clippings applications. NRCS recommends that organic wastes not be spread closer than the filter strip width (35 feet for this purpose).

Coarse soils (e.g., sand, loamy sand and sandy loam) have a higher susceptibility to leaching soluble nutrients (e.g., N). The leaching risk for a site can be estimated by the New Jersey Nutrient Leaching Index Risk (NRCS, 2001). If a field with coarse soils is selected for non-traditional organic waste application, care must be taken on the selection, rate, and timing of nutrients on fields with this type of soil. Generally, organic wastes used as N fertilizers are more prone to leaching than organic wastes that are used as soil conditioners. Organic wastes most likely to leach (e.g., N) should be avoided on soils with high leaching potentials. However, increasing the levels of organic matter in soil by selecting non-traditional organic wastes, that can be used as a soil conditioner, can increase the water-holding capacity. In addition, increasing levels of organic matter allow plant available nutrients to remain in the root zone longer to be utilized by crops or, allow soil microorganisms to convert nutrients in organic form to plant available forms which can be then used by crops.

The New Jersey Phosphorous Index (NRCS, 2001) can be used to evaluate the relative risk of P runoff to surface waters. Soils with a high adsorption capacity (soils with slow permeability and high pH, Fe or Al oxides, clay, and organic matter content) increase the likelihood of P moving off the field. If runoff from a field is a potential problem, common conservation practices to slow or prevent *pollutants* from leaving the fields can be found in the USDA/NRCS Field Office Technical Guide (FOTG, http://www.nj.nrcs.usda.gov/fotg/practices.html). These practices include *Grassed Waterway*, *Contour Buffer Strips*, *Filter Strips*, *Riparian Forest Buffer and Residue Management* that improve water storage, infiltration, and prevent run-off.

If soil suitability has been improved by management practices, the suitability of the soil for use of non-traditional organic waste products should be indicated in the RMS.

5. Appropriate Crops and Cropping Patterns

Appropriate crops on fields where non-traditional organic wastes are applied include field crops such as legumes, ornamental nursery stock, and to a lesser degree vegetable and fruit crops. Which crops and cropping patterns are most suitable depends on the time of the year that wastes become available, how the wastes are processed, and if the wastes are used as a N fertilizer or as a soil conditioner.

The availability of food processing by-products and yard wastes varies over the year. For example, the greatest amounts of grass clippings are produced in May and June. As a result, the immediate application of grass clippings to land at this point in the growing season allows time for production of only a few crops that are major users of N. Potential crops for grass clipping amended soil may include: field corn, sweet corn, and fall vegetable crops.

Some food processing wastes are heated in a food processing plant at high temperatures which can reduce potential pathogens (e.g., tomato skins and seeds are cooked with the tomatoes when making tomato sauce). If the waste is not processed (e.g., grass clippings that might contain animal pathogens from pet droppings), it would be better not to grow vegetable and fruit crops that touch the non-traditional wastes and are eaten raw, until further research has evaluated this issue. Unprocessed non-traditional organic wastes can also be carriers of plant pathogens and weed seeds.

Crops with high N requirements are recommended to grow on soils amended with organic wastes that are used as N fertilizer including grass clippings and many food processing vegetative wastes. These organic wastes are high in readily available N, which is released very quickly when land applied and tilled in. Crops that can use this N need to be planted very soon after waste application to land. Nitrogen demanding crops can be alternated with a legume crop.

Legume crops that produce nodules to supply N by fixation are recommended for soils where high C/N organic wastes used as soil conditioners have been applied, such as leaves or coffee grinds.

Non-harvested cover crops during the winter help to make use of and recycle residual N. Consider cover crops if you use non-traditional wastes as N fertilizers. This helps to reduce leaching of residual nitrate during the winter.

6. Application Rates

Application rates of non-traditional organic wastes should be selected in a manner to optimize crop growth (Garrison, 2002, RCE, 1994) and at the same time minimize environmental impacts. First, it needs to be determined which waste characteristic (e.g., N, pH, moisture, oils and fats) or soil property (e.g., P, pH, organic matter) limits the application rate due to its potential negative impact on crop production and the environment. The actual application rate is calculated based on the most limiting characteristic. If there are several possible limiting waste characteristics or soil properties, application rates are determined for all possible limiting waste characteristics and soil properties and the lowest calculated application rate is chosen as the actual application rate.

Set application rates are difficult to determine for these non-traditional wastes because characteristics of the organic wastes are highly variable and, with some wastes, constantly changing due to handling and storage. Furthermore, documented research evaluating application rates of the different types of organic wastes under various environmental conditions is very limited.

Because not every limiting waste characteristic and soil property can be discussed, in the following sections application rates based on the most common cases are presented: N content of waste, soil P and soil organic matter.

6.1 Application Rate Based on N Content of Waste/N Fertilizer

In most cases, the major limiting characteristic for non-traditional organic wastes used as a N fertilizer is N content. If N is the most limiting constituent, the application rate should be based on the N content of the organic waste, the estimated N availability, and the crop N requirement. Because of the variability of N content and

N availability in organic wastes a conservative approach is recommended if nitrate leaching is a concern. A conservative approach means that organic wastes are supplied below calculated N crop needs and additional N is supplied based on a soil nitrate test about four weeks after planting (see also RCE fact sheet FS569, *Pre-sidedress Soil Nitrate Test (PSNT)*: Recommendations for Field Corn). As part of this conservative approach, it is suggested that only 50 to 70% of the crop N requirement is supplied by the food processing waste if the application rate is based on N availability determined in the field. Alternatively, N availability data determined in the laboratory are used to calculate application rates. This approach is also conservative, because the N availability determined in the laboratory is an overestimation of the actual available nitrogen.

– Example calculation for string beans and green pepper waste:

Characteristics:
15% total solids (laboratory analysis)
3.41% total Kjeldahl N (laboratory analysis)
0.00% nitrate N (laboratory analysis)
3.41% total N (3.41% + 0.00%)
28.0% (N availability determined in the laboratory, see Table 2)
200 lb N/acre crop N need
1000 lb/yd^3 (bulk density, laboratory analysis or self-determined)

N fertilizer equivalent (NFE)
= 28.0 % x 1/100% x 3.41% = 0.95%

Available N in waste
= 0.95 x 1/100% x 2000 lb/dry ton
= 19 lb N/dry ton

Application rate
= 200 lb N/acre /19 lb N/dry ton = 10.5 dry ton/acre
= 10.5 dry ton/acre /(15% x 1/100%) = 70.0 wet ton/acre
= 70.0 wet ton/acre x 2000 lb/ton /1000 lb/yd^3 = 140.0 yd^3/acre
= 140.0 yd^3/acre /4833 yd^2/acre x 36 in / 1 yd = 1.0 in

– Example calculation for grass clippings:

Characteristics:
47% total solids (laboratory analysis)
3.04% total Kjeldahl N (Table 4)
0.00% nitrate N (Table 4)
3.04% total N (3.04% + 0.00%)
30.0% (N availability determined in the field)
150 lb N/acre crop N need
Only 70% of crop N need should be covered by grass clippings
371 lb/yd^3 (bulk density, laboratory analysis or self-determined)

N fertilizer equivalent (NFE)
= 30.0 % x 1/100% x 3.04% = 0.91%

Available N in waste
= 0.91 x 1/100% x 2000 lb/dry ton
= 18 lb N/dry ton

Application rate
= 150 lb N/acre x 70.0 % x1/100% /18 lb N/dry ton = 5.8 dry ton/acre
= 5.8 dry ton/acre / (47 % x 1/100%) = 12.4 wet ton/acre
= 12.4 wet ton/acre x 2000 lb/ton /371 lb/yd^3 = 67.0 yd^3/acre
= 67.0 yd^3/acre / 4833 yd^2/acre x 36 in /1 yd = 0.5 in

If no field or laboratory N availability data are available, it is suggested that only low amounts of organic wastes are applied (0.5 to 1 in). If a particular organic waste is applied on a regular basis, it is suggested testing soil nitrate and ammonium at the end of the growing season to determine the residual available N and possibly setting up test plots with different application rates. This will help to determine how the organic waste mineralizes. Contact your local agricultural agent if you need help to set up some test plots.

6.2 Application Rate Based on Optimum Soil P Levels

The P present in organic wastes is of greatest benefit when applied to soils that have below optimum soil P levels (less than 72 lb P/acre by the Mehlich-3 soil test method). On soils with optimum P levels (Mehlich-3 soil test: between 72 to 137 lb P/acre) the application rates of organic wastes should match the rate of P removal in harvested crops. On soils testing above optimum P levels (Mehlich-3 soil test: greater than 137 lb P/acre) a history of over-fertilization is indicated and the application of organic wastes or other sources of P is not suggested until the soil P level falls back into the optimum range. The sites with above optimum P levels can also be identified by the New Jersey Phosphorus Index (NRCS, 2001).

6.3 Application Rate Based on Soil Organic Matter/Soil Conditioner

Application rates based on soil organic matter is most common if non-traditional wastes are used as soil conditioners. Soil conditioners are applied at higher application rates to have an effect on the soil organic matter. If too much organic matter is applied, ground preparation and seed germination might be delayed. The application rates will vary depending on the waste.

The recommended application rate for leaves is 3 to 6 inches based on a three-year study conducted at Rutgers University. The 3-inch leaf application rate might be preferable because it reduces the possibility of delayed ground preparation and seed germination in a wet spring. For more information on leaf application see RCE fact sheets FS820, On-Farm-Mulching: Getting Started, FS821, On-Farm-Mulching: Leaf Application, Incorporation, and Economics, and FS822, On-Farm-Mulching: Effects on Soils, Crop Yield, and Pests.

Unless rates have been tested prior to application (e.g., leaves), low amounts of organic wastes should be applied (1.0 to 2.0 in) and, possibly test plots with different application rates should be set up. Contact your local county agricultural agent if you need help to set up some test plots.

Organic wastes with high C/N ratios, applied to farmlands as soil conditioners, can cause immobilization of N in the soil (see table 2). In certain soils, immobilization of soil N by the soil microbial community can cause crop N deficiency. Crop N deficiency can be alleviated if additional inorganic fertilizer is applied that provides a readily available N source for the plant. For example, an additional 50 lb/acre of N fertilizer sidedressed in band is recommended for corn grown the first year after leaf application to increase yields (Heckman and Kluchinski, 1996, Heckman and Kluchinski, 2000b, RCE fact sheet FS824, Plant Nutrients in Municipal Leaves). Another option is to plant legume crops that produce nodules to supply N by fixation. Soybeans can be grown without an initial supplemental N fertilizer but 20 to 30 lbs of starter N banded beside the row at planting may benefit the crop.

7. Receiving Area, Application Methods, Timing, and Equipment

An all-weather road and receiving area should be planned for the delivery of non-traditional organic wastes. The receiving area should be located where no run-off reaches surface water and delivery should be avoided if precipitation is expected. The receiving area should be close to the fields but away from the property line. This is especially important for organic wastes used as N fertilizer that are more prone to release odors and contaminate water. For example, for grass clippings, which can be very odorous, a distance of 1,000 feet to the property line of an area of human use or occupancy is required (see section 2).

Municipal yard wastes might contain some debris (trash). Loads that contain visible amounts of debris should be rejected. However, even loads with no visible amounts of debris might contain some unwanted materials. Therefore, an area next to the receiving area should be designated for collecting of the debris.

Equipment necessary for handling the organic wastes on the farm is relatively simple. A rear or side-delivery manure spreader and a tractor front end loader will be needed for loading and spreading the food processing by-products or yard wastes. The manure spreader should be calibrated. Organic wastes should only be spread when the soil is dry and thawed.

The best equipment for incorporation will vary depending on soil type of the field, crop being grown as well as type and amount of organic waste being spread. Chisel plows and rototillers tend to work well with leaf incorporation while moldboard plow and offset disc do not (Fritz and Graves 1992). Field applications should be rotated so that the material is not applied to the same field year after year.

The organic wastes should be incorporated evenly within the top 4 to 6 inches of soil. Incorporation helps the wastes degrade, reduces odors, and prevents wind blowing light organic wastes such as leaves. In addition, mixing the waste with the soil reduces run-off of organic wastes and volatilization of ammonia from organic wastes used as N fertilizer. However, incorporation might negatively affect crop residue cover and, therefore, increase soil erosion.

Application and incorporation of organic wastes used as N fertilizers should be done within 24 hours and most other organic wastes should be incorporated within 48 hours after delivery. Independent of the nutrient content of the organic waste, NJDEP, Bureau of Pretreatment and Residuals requires that food processing by-products be incorporated within 48 hours after delivery unless the slope of the land is less than 5% or crop residues or a vegetative land cover covers at least 75% of the land to prevent run-off (see section 2). According to state regulations municipal leaves can stay on the field after a fall application until incorporation in the following spring (see section 2). However, earlier leaf incorporation is advisable because it helps to break down the leaves and therefore improves field preparation and crop planting in the spring.

Organic wastes, improperly handled, are usually the source of odor and vector attraction. Most odor complaints from wastes occur during and after surface spreading to the land. Avoid these complaints by contacting close neighbors before spreading and by spreading the wastes at mutually acceptable times (for example, when the wind is blowing away from neighbors and on weekdays). With quick incorporation most odors can be avoided. Grass clippings, in particular, emit odors caused by their high N content which increases demand for oxygen and their tendency to mat, thereby reducing the passage of oxygen. These particular conditions cause grass clippings to become anaerobic very quickly and emit unpleasant odors (see RCE fact sheet FS389, Minimizing Waste Disposal: Grass Clippings).

8. Soil Management, Monitoring, and Record Keeping

8.1 Soil Management and Monitoring

Soil management is necessary to create soil chemical, physical and biological conditions that encourage plant growth and supply required nutrients in the amounts and at the times they are most needed. Maximizing the economic benefits of non-traditional organic wastes, as either a source of additional plant nutrients, or soil conditioner while minimizing environmental impacts can be encouraged through a combination of soil management techniques.

Soil testing provides a guide to determine the available nutrient status of a soil. The standard soil fertility test reports soil pH, N, P, K, Mg and Ca and recommendations for fertilization and liming. Additional tests for soil salinity (electrical conductivity) and organic matter content are completed on request. Typically a soil test is recommended every three years. However, repeated application of organic wastes, especially organic wastes being used as fertilizers, may cause nutrients to accumulate in the soil and carry over to future growing seasons. For example, repeated yard waste applications can accumulate K and P in the soil. Annual soil testing is recommended to account for residual nutrients in the soil and help determine crop needs and *nutrient management* decisions. Plant tissue analysis can also be used in conjunction with soil testing to determine actual plant uptake of nutrients.

The optimum values for soil nutrients, pH and electrical conductivity are site specific and a soil testing laboratory recommendation will vary depending on the crop. If a recent soil test indicates the application of organic waste to the soil does not provide the suggested P, K and Mg requirements for the crops, inorganic fertilizers should be applied before planting. In general, a soil pH between 6.0 to 7.0 is an acceptable range for most crops. If the pH of the soil drops below 6.0, lime should be added to raise the pH to maintain agricultural productivity and application of organic wastes with low pHs should be avoided. If the electrical conductivity of the soil is elevated above the optimum range of 0 to 0.8 mmhos/cm, organic wastes with relatively high soluble salts should not be applied (see section 3).

The Pre-sidedress Soil Nitrate Test (PSNT) (Magdoff, 1991) is an in-season test that should be used to monitor the soil for plant available N from organic wastes in fields with corn or certain vegetable crops. For example, when the PSNT test is used for field corn, soil samples are collected from the 0 to 12 inch depth when corn plants are between 6 and 12 inches tall. If the soil nitrate N concentration is 25 ppm nitrate N or greater, the soil N supply is sufficient for corn production. If the soil nitrate N concentration is less than 25 ppm, additional nitrate N sidedress N fertilizer is recommended. Soil nitrate N greater than 50 ppm nitrate N suggests that an excessive amount of N was applied to the soil (see RCE fact sheet FS569, Pre-sidedress Soil Nitrate Test (PSNT): Recommendations for Field Corn, draft RCE fact sheet, Soil Nitrate Testing as a Guide to Nitrogen Management for Vegetable Crops and Krogmann et al., 2001). Even though the PSNT test is only calibrated for corn and certain vegetable crops in New Jersey, the soil nitrate test is also useful for estimating N availability for other crops. If organic wastes are supplied below calculated N needs, additional N should be supplied based on a soil nitrate test about four weeks after planting.

The addition of organic wastes must not cause soil concentration of heavy metals and other contaminants to exceed any soil standards specified by RCE (see RCE fact sheet FS954, Land Application of Sewage Sludge (Biosolids), #4: Guidelines for Land Application in Agriculture), NJDEP or other state or federal regulatory agencies. The soil heavy metal concentrations may be determined by actual analysis or calculated using the application rate and the composition of the material applied. The amount of heavy metals added over time can be estimated by summing the annual increases in the soil heavy metal concentrations. It can be estimated by the following formula:

Increase in soil heavy metal concentration (mg/kg) = heavy metal conc. in organic waste (mg/kg) x application rate (dry ton/acre) x 0.001.

Organic wastes used as soil conditioner sources will initially impact the soil physical properties and structure rather than provide plant nutrients. Organic matter in soil can impact the water content, infiltration rate, and bulk density of soil. The infiltration rate, the rate at which water enters the soil, is dependent on the soil type, soil structure, and soil water content. A guide on how to quantify these soil indicators in the field, USDA Soil Quality Test Kit Guide, can be obtained from the NRCS Soil Quality Institute website at http://soils.usda.gov/sqi/kit2.html. The farmer can annually monitor impacts on soil structure by completing a Soil Quality Assessment Worksheet found in the USDA/NRCS FOTG (NRCS, 2002).

Tilling is used for incorporating the organic wastes into the soil. Topsoil erosion and rate of decomposition of soil organic matter are influenced by tillage practices. The more a soil is disturbed by tillage practices, the greater the potential breakdown of organic matter by soil organisms. However, tillage also breaks down natural soil aggregates and destroys large, water conducting channels. *Conservation tillage* practices that cause less soil disturbance than conventional moldboard plow and disk tillage are particularly recommended in erodible fields.

8.2 Resource Management System (RMS, formerly Farm Conservation Plan)

A RMS should be fully implemented and reviewed before application of non-traditional organic wastes. A RMS should be developed in conjunction with NRCS or third party vendors like Certified Crop Advisors according to the standards and specifications of the USDA/NRCS FOTG (NRCS, 2002) and approved by the local Soil Conservation District (SCD). A RMS addresses all resource concerns of the farm. This includes erosion control, pest management, crop rotation, pasture management, nutrient management, wildlife considerations, etc. The RMS should be updated when management practices improve a particular field.

8.3 Record Keeping

State record keeping and monitoring requirements should be fulfilled. Records should be kept by the farmer that include analyses (wastes and soil) and management practices for each of the fields of application. The record should also include name of the generator, the type and amount of the material applied, waste application methods, the date of application and field location, and calibration date of application equipment. In addition, the farmer should maintain records of the crops grown and yield from each field to which organic wastes have been applied. The records should be kept for at least five years. Written permission should be obtained from the landowner if a farmer wants to apply any non-traditional waste to leased or rented farmland.

APPENDIX 1

New Jersey Department of Environmental Protection

NJDEP, Division of Water Quality, Bureau of Pretreatment and Residuals
Tim Doutt (food processing by-products that are part of NJPDES permit)
401 East State Street
Trenton, NJ 08625-0029
Tel: (609) 633-3823
http://www.state.nj.us/dep/dwq/bpr/

NJDEP, Division of Solid and Hazardous Waste, Bureau of Resource Recovery and Technical Programs
Tim Bartle (yard wastes) and Paul Mander (food processing by-products, beneficial use projects)
401 East State Street
Trenton, NJ 08625-0029
Tel: (609) 984-6664 (Tim Bartle) and (609) 984-6985 (Paul Mander)
http://www.state.nj.us/dep/dshw/rrtp/

New Jersey Agricultural Experiment Station
SOIL TESTING LABORATORY

P.O. Box 902
Milltown, NJ 08850
Tel: (732) 932-9295

Natural Resources Conservation Service (NRCS)
Programs and Offices

Local Offices:

Flemington Service Center
Hunterdon, Somerset, and Union Counties
District Conservationist
4 Gauntt Place
Flemington, NJ 08822
(908) 782-3915
Fax: (908) 788-0795

Freehold Service Center
Mercer, Middlesex and Monmouth Counties
District Conservationist
303 West Main Street
Freehold, NJ 07728
(732) 462-1079
Fax: (732) 462-3499

Hackettstown Service Center
Sussex and Warren Counties
District Conservationist
101 Bilby Road, Building # 1
Hackettstown, NJ 07840
(908) 852-5450
Fax: (908) 852-4666

Morristown Urban Conservation Project Office
Bergen, Essex, Hudson, Morris, Somerset and Passaic Counties
District Conservationist
PO Box 900, Court House
Morristown, NJ 07963-0900
(973) 538-1552
Fax: (973) 285-8345

Mount Holly Service Center
Burlington, Camden, and Ocean Counties
District Conservationist
RD #2, 2615 Route 38
Tiffany Square, Suite 101A
Mount Holly, NJ 08060
(609) 267-0811
Fax: (609) 261-3007

Vineland Service Center
Atlantic, Cape May, and Cumberland Counties
District Conservationist
Building 3, Suite A
1317 South Main Road
Vineland, NJ 08360
(856) 205-1225
Fax: (856) 205-0691

Woodstown Service Center
Gloucester and Salem Counties
District Conservationist
51 Cheney Road Suite #2
Woodstown, NJ 08098
(856) 769-2790
Fax: (856) 769-0718

NRCS State and Regional Offices:

New Jersey State NRCS Office
State Conservationist
1370 Hamilton Street
Somerset, NJ 08873
(732) 246-1205
Fax:(732) 246-2358

Plant Materials Center
PMC Manager
1536 Route 9 North
Cape May Court House, NJ 08210
(609) 465-5901
Fax: (609) 465-9284

North Jersey Field Support Office
Hunterdon, Somerset, Union, Sussex and Warren Counties
North Jersey RC&D Coordinator
Box 3 Suite 21
1322 Route 31 North
Annandale, NJ 08801
(908) 735-0737
Fax: (908) 735-0744

Central Jersey Field Support Office
Burlington, Camden, Ocean, Mercer, Middlesex, and Monmouth Counties
Resource Conservationist
1370 Hamilton Street
Somerset, NJ 08873
(908) 246-1205
Fax (908) 246-2358

South Jersey Field Support Office
Atlantic, Cape May, Cumberland, Gloucester, and Salem Counties
South Jersey RC&D Coordinator
251 Bellevue Avenue
Hammonton, NJ 08037
(609) 561-3223
Fax: (609) 561-2765

Rutgers Cooperative Extension County Offices

Atlantic
6260 Old Harding Highway
Mays Landing, NJ 08330-1533
(609) 625-0056
Fax: (609) 625-3646

Bergen
327 Ridgewood Avenue
Paramus, NJ 07652-4896
(201) 634-2891
Fax: (201) 634-3008

Burlington
122 High Street
Mount Holly, NJ 08060-1317
(609) 265-5050
Fax: (609) 265-5613

Camden
152 Ohio Avenue
Clementon, NJ 08021-4184
(856) 566-2900
Fax: (856) 566-2907

Cape May
4 Moore Road
Cape May Court House, NJ 08210-1601
(609) 465-5115
Fax: (609) 465-5953

Cumberland
Extension Education Center
291 Morton Avenue
Millville, NJ 08332-9776
(856) 451-2800
Fax: (856) 451-4206

Essex
115 Clifton Avenue
Newark, NJ 07104
(973) 228-2210
Fax: (973) 481-5261

Gloucester
1200 N. Delsea Drive
County Gov. Services Bldg.
Clayton, NJ 08312-1095
(856) 307-6450
Fax: (856) 881-4191

Hunterdon
4 Gauntt Place
Flemington, NJ 08822-2900
(908) 788-1342
Fax: (908) 806-4735

Mercer
930 Spruce Street
Trenton, NJ 08648-4584
(609) 989-6830
Fax: (609) 396-9573

Middlesex
390 George Street, 8th Floor
New Brunswick, NJ 08901-2018
(732) 745-3443
Fax: (732) 745-3478

Monmouth
20 Court Street
Freehold, NJ 07728-1702
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APPENDIX 2
Characteristics of additional non-traditional organic wastes in New Jersey (summary of NJDEP data)

Waste type		No. of samples	pH	Total solids %	NH_4-N	NO_3-N	TKN	K	P
						% dry wt			
Food processing vegetative waste									
Vegetative (4/97 - 12 /97)	average	9		7.98			5.65	0.99	0.18
	range			(4.41 - 10.76)			(3.82 - 7.32)	(0.43 - 2.54)	(0.04 - 0.34)
Food processing non-vegetative waste and food processing residuals									
Clam processing (Thixotropic dark brown liquid)		1	6.96	20.03	0.46	<.0012	2.50	13.00	0.53
Coffee and tea concentrate sludge 1997		1	5.40	0.90	0.04	<0.01	0.06	1.13	0.92
Coffee and tea concentrate sludge 1998		1	5.90	1.46	0.074^	ND	4.64^**	1.16	3.61
Cranberry vegetated peat/sludge from lagoon 1997		1		10.20	1.21	0.002	6.10	0.22	0.76
Cranberry vegetated peat/sludge from lagoon 1998	average	10		11.20	1.87	0.20	4.72	0.27	1.23
	range			(9.1 - 12.40)	(0.059 - 10.64)	(<0.0002 - 0.0240)	(0.59 - 10.68)	(0.11 - 0.37)	(0.087 - 5.0)
Cranberry vegetated peat/sludge from lagoon 1999		1		10.00	0.23	<0.02	7.48	0.55	1.20
Dairy sludge 1985	average	2		1.95	0.36	0.04	4.06	1.40	1.17
	range			(2.00 - 1.90)	(0.18 - 0.54)	(0.03 - 0.05)	(1.6 - 6.51)	NA	(0.87 - 1.49)
Dairy sludge monthly 3/87 - 12/87	average	10		2.46	0.36	0.11	3.66	1.40	2.05
	range			(0.7 - 4.62)	(0.003 - 0.74)	(0 - 1.01)	(0.70 - 10.02)	NA	(0.21 - 5.70)
Dairy sludge 1988	average	4		2.53	0.64	0.05	2.72	1.40	2.15
	range			(1.5 - 4.00)	(0.14 - 0.86)	(0.004 - 0.13)	(0.12 - 5.26)	NA	(0.47 - 5.70)
Dairy sludge 1989	average	5		2.82	0.58	0.05	3.61	1.40	1.01
	range			(2.09 - 3.6)	(0.15 - 1.00)	(0.03 - 0.08)	(2.07 - 5.25)	NA	(0.14 - 2.25)
Dairy sludge 1989		1	6.37	3.10	0.01	0.003	0.14	NA	0.10
Fruit juices/belt filter press 1998		1	6.32	8.60	0.03	<0.012	4.00	0.59	0.45
Fruit juices residuals-lagoon sediment 1997		1	5.10	6.63	0.02	ND	28.2**	1.45	2.88
Hydrolysed plant protein (wheat, corn, soy and other grains) in bouillon cube/seasoning production 1997		1	5.40	60.00	0.41	0.0002	5.1	0.09	0.68
Licorice root fibers & soil/settling tank & baghouse cleanout 1997		1	12.20	73.80	0.01	0.0006	NA	ND	0.25
Meatball & pasta residuals/DAF* (1997 - 1998)	average	2	4.70	5.90	0.16	ND	1.76	0.40	0.44
	range		(4.6 - 4.8)	(4.23 - 7.57)	(ND - 0.31)		(0.81 - 2.71)	(0.26 - 0.53)	(0.42 - 0.47)
Pepper processing sludge (metals 1993/nutrients 1996)		1	7.30	9.16	0.01	ND	0.93	1.90	0.40
Poultry processing residual/DAF* 1993		1	5.40	7.10	0.93	<0.0001	3.20	3.12	0.27
Seafood sludge (inactive in NJ - 7/1997)	average	6	na	3.88	0.72	0.01	7.56	NA	0.63
	range			(2.51 - 5.76)	(0.24 - 1.31)	(0 - 0.02)	(4.11 - 10.90)	NA	(0.07 - 2.13)
Seafood sludge (inactive in NJ - 12/1997)		1	4.51	3.90	0.01	0.01	0.09	4.12	0.31

ND - not detected NA - not available *DAF - dissolved air flotation

**Values from analysis should be evaluated further ^Value from waste as received and not dry wt basis

APPENDIX 2 (continued)
Characteristics of additional non-traditional organic wastes in New Jersey (summary of NJDEP data)

Waste type	No. of samples	Oil & drease	Phenol	Cd	Cu	Pb	Ni	Zn	As	Be	Cr	Hg	Mo	Se	Na	Fe
		% dry wt	ppm													
Food processing vegetative waste																
Vegetative (4/97 - 12 /97)																
Food processing non-vegetative waste and food processing residuals																
Clam processing (Thixotropic dark brown liquid)	1	0.21														
Coffee and tea concentrate sludge 1997	1	0.5^	2153.00	<44.4**	233.00	17.30	253.00	388.00	<1.11	<55.5	428.00	<0.555	<166	<1.11		5106.0
Coffee and tea concentrate sludge 1998																
Cranberry vegetated peat/sludge from lagoon 1997																
Cranberry vegetated peat/sludge from lagoon 1998	1															
Cranberry vegetated peat/sludge from lagoon 1999	1			<5	85.00	<50	5.00	750.00	<2.5				<50	0.62		
Dairy sludge 1985	1			2.00	83.00	30.00	17.00	180.00								
Dairy sludge monthly 3/87 - 12/87																
Dairy sludge 1988																
Dairy sludge 1989																
Dairy sludge 1989	1	0.19														
Fruit juices/belt filter press 1998	1	0.09	<0.7	<1	29.00	3.50	23.00	<0.7	6.50	<0.02	<1	1300**	23.00	<0.7		1300.0
Fruit juices residuals-lagoon sediment 1997	1	0.06	ND	5.49	91.10	44.30	46.00	3080.00	ND	0.20	82.70	0.74	14.40	0.63		52300**
Hydrolysed plant protein (wheat, corn, soy and other grains) in bouillon cube/seasoning production 1997	1			ND	13.00	ND	ND	48.00			ND	ND	ND		53000	180.0
Licorice root fibers & soil/settling tank & baghouse cleanout 1997	1	0.22		ND												
Meatball & pasta residuals/DAF (1997 - 1998)	1	45.9	28.30	ND	26.30	3.41	4.70	67.40	ND	ND	7.04	1.14	ND	ND	5020	1290.0
Pepper processing sludge (metals 1993/ nutrients 1996)	1	8.04	52.00	1.00	65.00	7.00	8.30	114.00	0.39	0.18	9.50	<0.64	1.20	<0.19		5600.0
Poultry processing residual/DAF* 1998	1		5.90	4.00	28.00	4.00	18.00	460.00	<1.0	<0.71	4.00	<0.35	<3.5	<1.0		
Seafood sludge (inactive in NJ - 7/1997)																
Seafood sludge (inactive in NJ - 12/1997)	1	0.05	2.50	1.20	5.50	16.20	3.00	63.50	51.50	ND	3.10	0.05	ND	7.10		115.7

ND - not detected *DAF - dissolved air flotation **Values from analysis should be evaluated further

APPENDIX 3

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APPENDIX 4

Glossary

Anaerobic — Pertaining to or caused by the absence of air or oxygen.

Calcium carbonate equivalent (CCE) — An expression of the acid-neutralizing capacity of a carbonate rock relative to that for pure calcium carbonate. It is expressed as a weight percentage of calcium carbonate. Pure calcium carbonate is used as the standard with a neutralizing value of 100%. The actual CCE of most limestone will vary from this percentage due to impurities in the rock.

C/N ratio — Percent of organic carbon (dry weight) divided by the total N content of the material (dry weight). Organic carbon can be estimated by dividing the organic matter content by 1.72.

Certified laboratory — A laboratory certified by NJDEP in accordance with NJAC 7:18. NJDEP may be contacted for a list of state certified laboratories.

Conservation tillage — Any tillage and planting system that maintains at least 30% of the soil surface covered by residue after planting to reduce soil erosion by water.

Contour buffer strips — Strips of grass or legumes in a contoured field, which help to trap sediment and nutrients.

Dry weight basis — Calculated on the basis of having been dried at 1922^{O}F (105^{O}C) until reaching a constant mass. For example, if a total N content of a waste is reported as 1% on a dry weight basis, it means that 1% of the dry waste is nitrogen.

Fertilizer — Any substance that fertilizes the soil.

Filter strips — Strips of varying width, left in permanent vegetation between waterways and land uses, to intercept and filter pollutants before they enter a water resource.

Food processing by-products — Food processing vegetative wastes and/or food processing residuals generated from food processing and packaging operations or similar industries that process food products.

Food processing vegetative wastes — Peels, skins, and seeds left over from trimming, reject sorting, cleaning, pressing, cooking and other food processing operations.

Food processing residuals — Residuals resulting from the physical, chemical and/or biological treatment of wastewater generated in food processing and packaging operations or similar industries that process food products, whose application to lands would benefit crop growth and soil productivity. Food processing residuals do not include process wastewater.

General permit — NJDEP has developed a general NJPDES permit for land applied food processing vegetative wastes and food processing residuals for cases where no significant environmental issues (e.g., odors, pathogens) are expected. The application for inclusion under the general NJPDES permit is less rigorous than those required for an individual NJPDES permit. Also, individual permits typically contain additional permit requirements and reporting to NJDEP.

Generator — A person or municipality that produces or creates a waste.

Grassed waterway — A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff.

Immobilization — Making unavailable. For example, if wastes with a high C/N ratio such as leaves or wood chips are incorporated in the soil, there might be an immobilization of nitrogen. Soil microorganisms use the nitrogen for the degradation of the leaves and the wood chips, thereby making the nitrogen unavailable for plant growth.

Individual permit — In cases where significant environmental issues are expected for land application of food-processing by-products (e.g. odors, pathogens), a individual NJPDES permit is required.

Land application — The recycling, treatment, or disposal of wastewater, wastewater solids (biosolids) and food processing by-products to the land under controlled conditions. This includes the spraying or spreading onto the land surface; the injection below the land surface; or the incorporation into the soil so that the applied materials can either condition the soil or fertilize crops or vegetation grown in the soil, or both. NJDEP's definition: Controlled discharge of pollutants onto or into the surface soil horizon in such a manner that the materials are treated by and/or become incorporated into and blended with soil.

Land capability classification — A grouping of soils into special units, subclasses, and classes according to their capability for intensive use and the treatments required for sustained use. One such system has been prepared by the USDA Natural Resources Conservation Service (NRCS) (Soil Conservation Service, 1973).

Mulch — Any material which is spread or allowed to remain on the soil surface to decrease the effects of raindrop impact, runoff, weeds, low soil moisture and other adverse conditions.

Nitrate N— A reduced form of nitrogen that is mobile in soils and can cause health problems for infants if the drinking water concentration exceeds 10 mg/l of nitrate N.

N availability — Percentage of the organic or the total N of the organic waste that becomes available in a growing season to plant available forms (NH_4-N and NO_3-N). In these guidelines, N availability refers to the percentage of total N of the organic waste.

N mineralization rate — Rate of conversion of organic nitrogen from the waste to plant available forms (NH_4-N and NO_3-N).

NJPDES permit — A permit needed to discharge pollutants into ground water, streams, rivers, and the ocean. In New Jersey, a New Jersey Pollutant Discharge permit is needed.

Non-traditional organic wastes — Food processing by-products and municipal yard wastes.

Nutrient management — A practice designed to minimize the amount of nutrients (usually nitrogen and phosphorus) applied to the soil to no more than the crop is expected to use. This may involve changing fertilizer application techniques, placement, rate, or timing.

Nutrient management plan — A plan outlining the nutrient management practices.

Odor — An unpleasant smell, which has the tendency to attract vectors such as flies. Odors are mitigated through management practices such as incorporation of the food processing by-products into the soil. Odors released during application of food processing by-products can also be reduced if the wastes are processed, for example, by composting.

Pathogens — Disease-causing organisms. These include, but are not limited to, certain bacteria, protozoa, viruses.

Pollutant — A contaminant existing at a concentration high enough to endanger the environment, the public health, or to be otherwise objectionable. NJDEP's definition: dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, refuse, oil, grease, sewage sludge, munitions, chemical wastes, biological materials, medical wastes, radioactive substance, thermal waste, wrecked and discarded equipment, rock, sand, cellar dirt and industrial, municipal, agricultural, and construction waste or runoff or other residue discharged directly or indirectly to the land, ground waters or surface waters of the State, or to a DTW. "Pollutant" includes both hazardous and nonhazardous substances.

Pre-sidedress Soil Nitrate Test (PSNT) — Test that determines sidedress fertilizer needs for field corn and some vegetables at a time of highest plant nutrient needs.

Quality assurance/quality control plan — A plan that describes the quality assurance and quality control measures of a project. Quality assurance deals with operating an administrative system of management controls that cover planning, implementation, and review of data collection activities. Quality control is a technical function that includes all scientific precautions, such as calibrations and duplications, that are needed to acquire data of known and adequate quality.

Research, Development & Demonstration (RD&D) project — A RD&D project addresses the production of new useful materials, devices, systems, or methods. The project includes research, development, and demonstration components. "Research" is defined as a systematic study directed toward fuller scientific knowledge or understanding of the subject studied. "Development" is the systematic use of knowledge and understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including design and development of prototypes and processes. "Demonstration'' means a full-size implementation of the production of developed materials, devices, systems, or methods to gain knowledge about the full-size technology, plant operation, and process economics.

Residual N — Nitrogen that remains in the soil after the harvest of a crop. Residual nitrogen is either immediately available or will become available to the succeeding crop. Sources of residual nitrogen include previous sewage sludge (biosolids) applications, manure applications, crop residues, and non-traditional organic wastes.

Residue management — Managing the amount, orientation, and distribution of crop residues and other plant residues on the soil to reduce erosion, conserve water, and improve soil organic matter content.

Resource management system (RMS) —Information provided to a land user that includes guidance, alternatives, and decisions as needed to plan and apply resource management systems consistent with the National Conservation Planning Manual, Title 11, NRCS, USDA and the NJ Field Office Technical Guide (FOTG), as amended. A RMS developed in conjunction with NRCS and approved by the local Soil Conservation District (SCD) addresses all the resource concerns of the farm. This includes erosion control, pest management, crop rotation, pasture management, nutrient management, wildlife considerations, etc. The RMS was previously called farm conservation plan.

Riparian forest buffer — The area of land adjacent to the bank or shoreline of a body of water.

***Soil conditioner* —** Substance that contributes to the organic matter content of the soil, improves soil structure and aggregation and soil moisture retention.

Soil series — The set of all soils whose profiles are essentially alike, within narrowly defined ranges of variability. The soil series is the lowest unit of soil classification. Names of soil series are usually taken from geographic entities in areas where the soil was first described, for example, the Freehold Series, the Washington Series, and the Penn Series.

Soil texture **—** The proportions of soil particles (sand, silt and clay) in a soil.

***Total Kjeldahl N (TKN)* —** The total amount of organic and ammonia nitrogen present in organic samples such as soil organic matter, food processing by-products, etc., as determined by the Kjeldahl technique

User site **—** Farm land on which food processing by-products are to be land applied.

***Vector attraction*—** Characteristic of a waste that attracts rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents.

Waters of the State — the ocean and its estuaries, all springs, streams and bodies of surface or ground water, whether natural or artificial, within the boundaries of the State of New Jersey or subject to its jurisdiction.

Yard waste — Municipally collected leaves, grass clippings, woody brush and tree trimmings generated by residents, businesses and institutions.

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