COMPREHENSIVE NUTRIENT MANAGEMENT PLAN

Wil-View Farms

15135 S.W. Wilsonville Road
Wilsonville, OR 97070
(503) 625-5981

Prepared by:
Don McNiel

with assistance from:
Bruce D. Wilson
H&R Engineering, Inc.
Keizer, OR
(503) 881-4254

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SIGNATURE PAGE

OWNER/OPERATOR:	**Don McNeil**
Address & Phone:	**15135 S.W. Wilsonville Road Wilsonville, OR 97070 (503) 625-5981**
Farm and Tract No:	**USDA Tract 673 and 696**

I certify the Manure and Wastewater Handling and Storage Element meets the requirements of a CNMP.

Signature: Bruce D. Wilson	Date: 10/4/2005
Name: Bruce D. Wilson	
Title: Civil Engineer/PE	

I certify the Nutrient Management Element meets the requirements of a CNMP.

Signature: Bruce D. Wilson	Date: 10/4/2005
Name: Bruce D. Wilson	
Title: Civil Engineer/PE	

I certify the Land Treatment Practices Element meets the requirements of a CNMP.

Signature: Bruce D. Wilson	Date: 10/4/2005
Name: Bruce D. Wilson	
Title: Civil Engineer/PE	

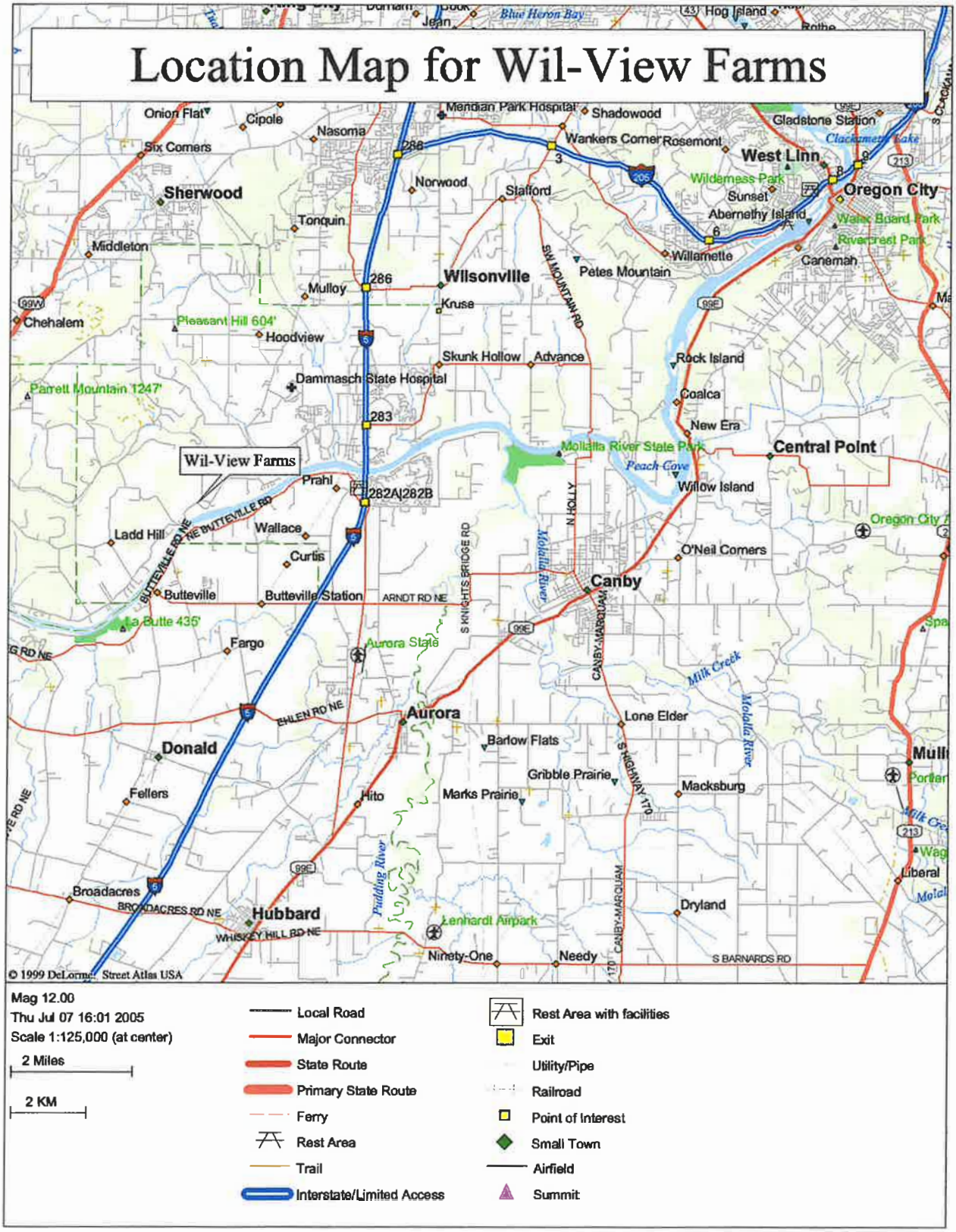
As the **Owner/Operator and Decision-Maker**, I certify that I have been involved in the planning process for the development of this CNMP. I understand my responsibilities for implementing and updating this CNMP in a timely manner and for keeping all necessary records.

Signature:	Date: 10/18/05

As a **Certified Conservation Planner**, I certify that I have reviewed this plan and have determined that it contains the deliverable items described in the NRCS Statement of Work for a CNMP and appears to be in conformance with NRCS planning policy.

Signature: L. Ko	Date: 11/14/05
Name: LEONDA KO	
Title: NRCS WATER QUALITY SPECIALIST	

GENERAL INFORMATION



GENERAL INFORMATION

This Comprehensive Nutrient Management Plan (CNMP) was developed in accordance with the USDA Natural Resources Conservation Service's Field Office Technical Guide and provides guidance for the wise use of the soil, water, air, plants and animal resources in order to minimize degradation of these resources such that public health and safety is protected. The plan provides guidance on what structural and management practices are needed to prevent the discharge of pollutants to surface or ground water by recycling wastes through the soil and plants to the fullest extent possible.

As owner of the Wil-View Farms, Don McNiel is responsible for the proper application of management practices and the Operation and Maintenance (O&M) of the structural practices. It is also the responsibility of Don McNiel to comply with all of the provisions and conditions outlined in the Confined Animal Feeding Operation (CAFO) permit administered by the Oregon Department of Agriculture. Any modifications to the operation which are not within the provisions and conditions of the CAFO permit must be reviewed and approved by the Oregon Department of Agriculture prior to implementation.

OBJECTIVES

Don McNiel has the following objectives:

1. Apply liquid and solid manure to obtain maximum nutrient benefit while eliminating runoff and minimizing leaching of nutrients.
2. Operate the farm in a socially and environmentally acceptable manner.

ANIMAL NUMBERS

The Wil-View Farms is currently milking 150 cows with 20 dry cows, 100 heifers, 50 calves and 50 bulls which are being cared for to support the dairy operation. The milk cows, dry cows, and heifers are confined from late November to late March and are pastured from early April to early November. The calves and bulls are kept in confinement all year.

There is no plan to increase animal numbers from the 370 currently being supported by the Wil-View Farms dairy operation but animal numbers could be increased to a maximum of 530 based on converting fields 1 and 2 shown on the plan map in Section 5 to pasture/hay land or crop land where manure and wastewater could be applied. The maximum population of 530 animals the Wil-View Farms dairy operation is based on 210 milking cows, 30 dry cows, 160 heifers, 80 calves and 50 bulls as shown in Section 4. The maximum population of 530 animals is also based on applying nutrients contained in manure and wastewater on a nitrogen basis as shown in Section 4.

COULD TO EXPAND ANY PLANS TO EXPAND? DOES ALWMP CONSIDER EXPANSION?

If the phosphorus index reaches a high site vulnerability class based on applying manure and wastewater on a nitrogen basis then either animal numbers on farm must be reduced or manure and wastewater exported off farm to be able to apply manure and wastewater on a phosphorus basis to keep the site vulnerability class from increasing.

WASTE MANAGEMENT SYSTEM

Following is a description of the waste management system for the Wil-View Farms shown on the facilities plan map in Section 4:

Collection- Manure and wastewater collected in the holding area and milk house during milking periods is drained to an existing underground reinforced concrete collection tank north of the milking parlor.

The manure and bedding generated in the freestall barns is collected on alleyways which are scraped to cell number one of a two cell waste storage pond.

Manure and bedding in the calf hutches is collected as a dry pack until cleanout when it is either transferred to an open reinforced concrete slab area near the silage storage area or land applied.

GENERAL INFORMATION

All contaminated rainfall runoff from paved areas is collected by directing runoff to cell number one of the two cell waste storage pond.

There are no planned improvements to the collection system. NO RECORD OF CONSTRUCTION PLANS/APPROVAL NEEDED ???

Storage- A new reinforced concrete slab is being constructed on the southwest side of the dry cow and calf barn to be used as a solids storage facility. The slab measures 60 feet by 140 feet long and considering a storage depth of 8 feet will provide 160 days of storage for solids which exceeds the 154 days recommended on the storage period worksheet OR10A-7 in Section 4.

The existing reinforced concrete collection tank near the milk house serves as a short term storage facility for manure and wastewater generated from holding area and milk house. Storage time for the collection tank varies from a few hours to several days depending on the amount of wastewater and contaminated runoff being produced. The collection tank was not designed and constructed with NRCS assistance. Based on the current condition of the collection tank it should continue to operate without causing environmental hazard to ground and surface waters as long as management guidelines are followed.

A circular reinforced concrete tank measuring 24 feet in diameter and 9 feet deep exists near the push off ramp for the waste storage pond. The tank used to serve as the primary storage facility for the dairy operation but has not been used as a storage facility since the waste storage pond was constructed. The tank is still in serviceable condition and could be used as a short term storage facility if needed. There are no plans to remove the tank as it poses no environmental hazard.

A two cell earthen waste storage pond serves as the long term storage facility for liquid manure, wastewater, and contaminated rainfall runoff. Solids buildup in Cell #1 of the waste storage pond is a problem and actions are being taken to agitate and remove as many solids as possible to gain back storage capacity in Cell #1. All solids removed from Cell #1 are planned to be exported off farm for utilization to reduce on farm phosphorus applications. According to NRCS as-built drawings of the waste storage pond, Cell #1 of the waste storage pond measures 50 feet by 203 feet on the bottom, is 10 feet deep with 3 to 1 side slopes and has a usable storage capacity of 3.9 acre feet. Cell #2 measures 285 feet by 200 feet on the bottom, is 10 feet deep with 3 to 1 side slopes and has a usable storage capacity of 14.7 acre feet. The total usable storage capacity of the waste storage pond is 18.6 acre feet which will provide 210 days of storage time for the number of animals and facilities described in this plan which exceeds the 158 days recommended on the storage period worksheet OR10A-7 in Section 4. This facility was constructed in accordance with NRCS plans and specifications and was certified by NRCS to meet the applicable standard at the time of construction.

If animal numbers are increased to a maximum of 530, the waste storage pond will still provide 160 days of storage which meets the recommended storage period of 154 days shown on worksheet OR10A-7 in section 4. Additional storage for solids may be needed if animal numbers are increased to meet the recommended storage period of 154 days shown on worksheet ORA10A-7. NOTE

There are no planned improvements to the manure storage facilities for the dairy.

Treatment- There are no designed treatment facilities other than what composting naturally occurs in the dry stack and naturally occurring anaerobic treatment in the waste storage pond.

No additional treatment facilities are planned for the dairy.

Transfer- Manure, bedding and wastewater collected in the reinforced concrete collection tank near the milk house is pumped onto the reinforced concrete slab area that drains to cell #1 of the waste storage pond.

GENERAL INFORMATION

During the spring and summer months the manure, bedding and wastewater stored in the waste storage pond is pumped to the utilization areas using under ground pipelines.

WHERE?

Accumulated solids and solids removed from cell #1 of the waste storage pond are planned to be exported off farm to reduce phosphorus applications to the utilization area and phosphorus concentrations in the soil profile.

No additional improvements to the transfer system are planned for the dairy.

Application- Currently a traveling Big Gun sprinkler is used to apply the liquids from the waste storage pond in accordance with nutrient application rates identified in Section 6 of this plan.

No additional improvements to the application system are planned for the dairy.

Utilization- There is approximately 86.5 acres of pasture/hay land and 42 acres of crop land available for utilization of the nutrients and organics contained in the liquids produced from the dairy.

Fields 3, 4, and 5 in tract 673 have a low site vulnerability class and fields 6, 7 and 8 in tract 673 and field 1 in tract 696 have a medium site vulnerability class based on the Western Oregon Phosphorus Index. Application of nutrients and organics are based on nitrogen in accordance with the site vulnerability class determined for each field.

AGAIN EXPORTED TO? WHEN? HOW OFTEN— WHY NOT CONSIDER COMPOSTING SOLIDS?

The acres available for application will utilized the nitrogen but not all of the phosphorus and potassium generated from the dairy operation. All solids are planned to be exported off farm to reduce phosphorus and potassium applications to on farm fields. Nutrient utilization rates for the pasture/hay land and crop land can be found Section 6 of this plan.

If animal numbers were increased to a maximum of 530, fields 1 and 2 would have to be converted to crop land or pasture/ hay land in order to be able to utilize all of the nitrogen produced from the dairy operation. Converting fields 1 and 2 to pasture/hay land would bring the total acres available to 135.7 acres of pasture/hay land and 42 acres of crop land for utilization of the nutrients and organics contained in the liquids and solids produced from the dairy.

CROPPING SYSTEM

The cropping system consists of perennial ryegrass grown for pasture and hay and corn silage to support the feed ration for the dairy herd. Ryegrass is planted after the corn silage is harvested to provide a cover crop during the fall and winter months to prevent excessive soil erosion. The ryegrass cover crop is harvested as haylage and grazed in the spring before the corn silage crop is planted. The acreage for each field where manure is applied can be found in Section 6 of this plan.

IRRIGATION SYSTEM

Currently a traveling Big Gun sprinkler system is used to irrigate the pasture/hay land and crop land. Guidance for irrigating the pasture/hay land and crop land during the production period to supply moisture for plant evapotranspiration is described in the irrigation water management part of Section 8 of this plan. The traveling Big Gun irrigator is also used to apply liquid waste generated from the dairy for utilization of nutrients and organics as described in the waste utilization part of Section 8 of this plan.

EMERGENCY RESPONSE PLAN

In Case of a Storage Facility Spill, Leak, or Failure

a. Stop all other activities to address the emergency.
b. Stop all flow into the storage facility.
c. If the storage facility is at maximum capacity or overtopping, draw the waste level in the facility down by making an application to the emergency application area shown on the plan map in accordance with the instructions in the Operations section of this plan.
d. Assess the extent of the emergency and determine how much help is needed to correct the problem.
e. Call for help & excavator if needed.
f. If possible, use a skid loader or tractor with blade to contain or divert spill or leak away from environmentally sensitive areas.
g. If containment material is needed, excavate soil from appropriate areas away from the storage facility.
h. If possible, begin pumping manure and spreading in the prescribed fields at the prescribed application rates.
i. Complete the clean-up and repair the necessary components.

In Case of a Manure/Waste Discharge

a. Stop all other activities to deal with the emergency.
b. Call for help if needed.
c. Call sheriffs office if spilled on road for traffic control and clean the spill immediately from the road and roadside if needed.
d. Contain the spill or runoff from entering the stream or waterway using straw bales, saw dust, or soil material.
e. If flow is coming from a tile, plug the tile with a tile plug immediately.
f. Assess the extent of the emergency and determine how much help is needed.

Contacts to be made within 24 Hours of a Discharge

(SEE NEXT PAGE FOR REQUIREMENTS FOR FILING A WRITTEN REPORT)

Organization	Phone
Oregon Department of Agriculture	**1-800-282-9378**
Oregon Emergency Response System (ORES)	**1-800-452-0311**

Be prepared to provide the following information:

a. Your Name (See next page)
b. Farm Identification (See next page)
c. Description of emergency.
d. Estimate of the amounts, area covered, and distance traveled.
e. Has manure reached surface waters or major field drains?
f. Is there any obvious damage: employee injury, fish kill, or property damage?
g. What is currently in progress to contain situation?

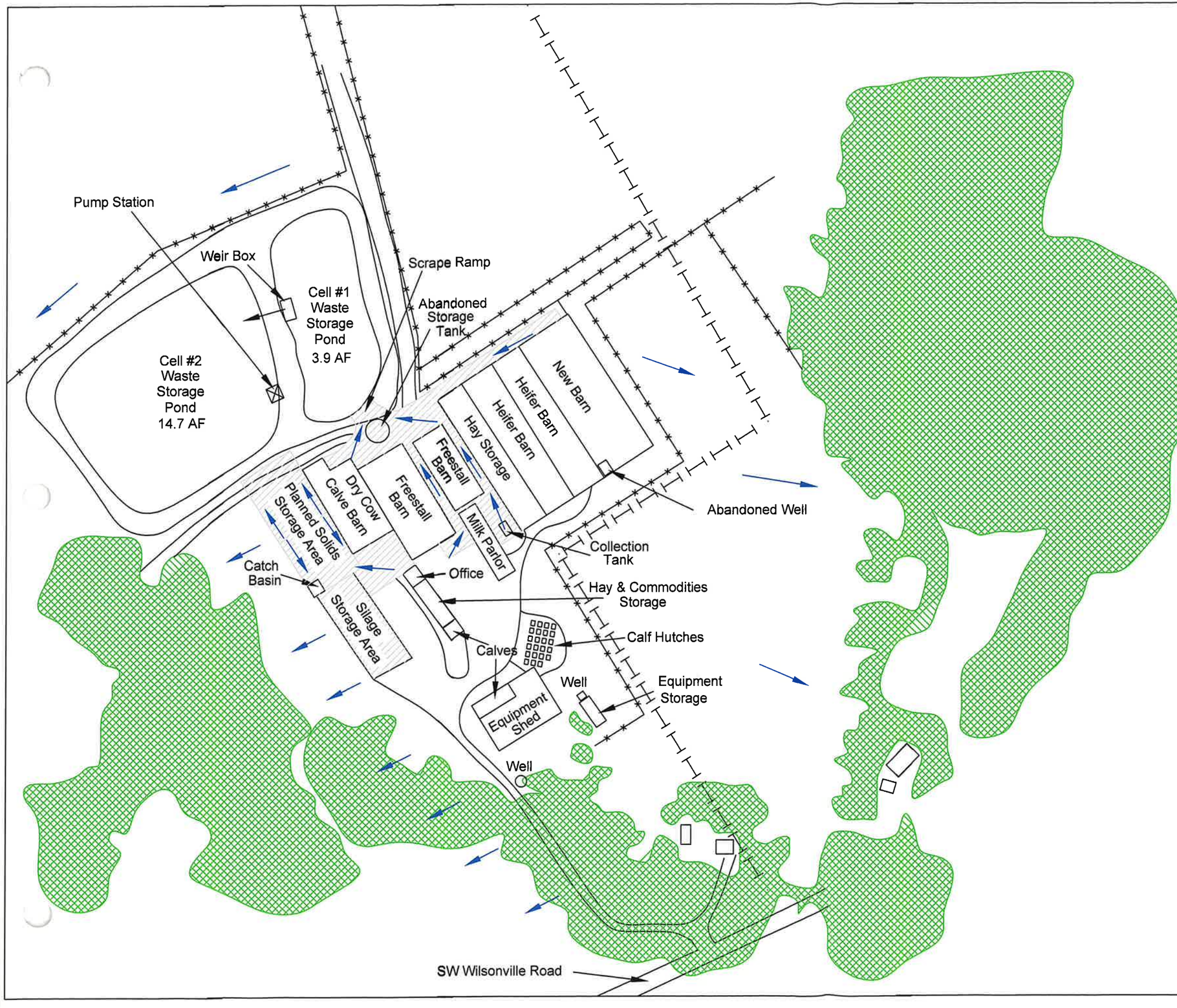
EMERGENCY RESPONSE PLAN

Emergency Contact Information

Farm Name	**Wil-View Farms**
Address	**15135 S.W. Wilsonville Road Wilsonville, OR 97070**
Farm Phone	**(503) 625-5981**
Permit #	
DIRECTIONS TO FARM	**From Interstate 5 take exit 283 and travel west on SW Wilsonville Road 3.9 miles to the entrance of Wil-View Farms which will be on your right.**
Emergency Phone Numbers:	
Farm Owner	**(503) 625-5981**
Farm Manager	**(503) 625-5981**
FIRE or AMBULANCE	**911**

If a Discharge Occurs a Written Report is to be made by Owner or Operator to Oregon Department of Agriculture within 5 Days that contains the following information: INSPECTOR ??

a. A description and cause of the discharge.
b. The period of discharge including exact dates, times and duration of discharge.
c. An estimate of discharge volume.
d. Name or location of receiving water.
e. Corrective steps taken, if appropriate, to reduce, eliminate or prevent reoccurrence of the discharge.



Facilities Plan Map

Client:Don McNiel Farm Name: Wil-View Farms

County: Clackamas State: Oregon

Approximate Acres: 8.2 Date:September 2005

Location: Section 18 T 3 S R 1 W

Assisted By: Bruce D. Wilson, H&R Engineering Inc.

100 0 100

SCALE IN FEET

Map Legend

- Paved Areas
- Fence
- Buried Manure Transfer and Irrigation Pipeline
- Drainage

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Basic Storage Period, SPb = 274 Days

Enter average monthly Evapotranspiration(**ET**) from OSU Extension Publication 8530, Oregon Crop Water Use and Irrigation Requirements, and Precipitation(**Ppt**) Data from

Climatic Station- N WILLAMETTE EXP STA

Crop - Corn Silage

Day of Year	MONTH	Crop ET, Inches	Accum Crop ET, Inches	Ppt, Inches
1-31	January	0.00	0.00	6.17
32-59	February	0.00	0.00	4.39
60-90	March	0.00	0.00	3.99
91-120	April	0.00	0.00	2.64
121-151	May	1.22	1.22	2.17
152-181	June	4.17	5.39	1.73
182-212	July	7.13	12.52	0.70
213-243	August	5.91	18.43	0.94
244-273	September	1.14	19.57	1.84
274-304	October	0.00	19.57	3.11
305-334	November	0.00	19.57	6.03
335-365	December	0.00	19.57	7.09

a. Determine last day for the month of the year when 3/4 of Annual ET is exceeded-

3/4 of Annual ET = 0.75 x 19.57 = 14.68 Inches

L = Last Day for Month Accum ET exceeds 3/4 of Annual ET

L = 243 Days

b. Determine first day for the month of the year when ET >= Ppt-

E = First Day of Month ET >= Ppt

E = 152 Days

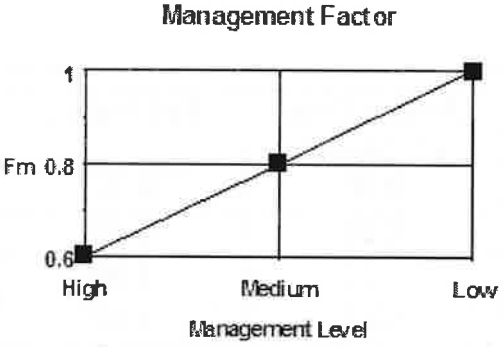
c. **SPb =** 365 - (L - E) = 365 - (243 - 152) = 274 **Days**

Sheet 1 of 4

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Management Factor, Fm = 0.8



Low Level, Fm = 1.0
...The operator does not utilize a waste management plan.
...Proper operation and maintenance may not be performed.

Medium Level, Fm = 0.8
...The operator utilizes an up-to-date waste management plan.
...Manure application equipment is calibrated for nutrient applications.
...Maintains adequate soil moisture for crop growth.
...Agronomic treatments which would maximize crop nutrient uptake are not fully utilized.
...Proper operation and maintenance is planned.

High Level, Fm = 0.6
...The operator utilizes an up-to-date waste management plan.
...Soil fertility testing is performed annually.
...Manure in storage is tested for nutrient concentrations.
...Records of time, rate and location of manure applications are maintained.
...Manure application equipment is calibrated for nutrient applications.
...Irrigation water management techniques are practiced.
...Crop nutrient uptake is maximized with appropriate agronomic treatments such as residue management, conservation crop rotation, crop variety selection, prescribed grazing, and pest management.
...Proper operation and maintenance is planned.

Soils Factor: Fs_{LIQUID} = **0.85** Fs_{SOLID} = **0.65**

Soils must meet the following criteria for Fs to be less than 1.0-
...The average water holding capacity for the profile greater than 3.0 inches.
... A cation exchange capacity greater than 5 meq/100g of soil.
... Depth to a thin layer/cemented pan greater than 20 inches.
... Depth to high water table greater than 2 feet.
... A permeability greater than 0.06 inches/hr but less than 6 inches/hr.
... Cobbles less than 35% by weight in the surface layer.
... Stones and boulders less than 15% by weight in the surface layer.
... A pH greater than 5.0.
... Sodium Adsorption Ratio less than 13.
... Land slope less than 15%.

Soils Factor (Fs)

HSG	Consistency of Waste			
	Liquid	Slurry	Semi-Solid	Solid
A	1.00	0.95	0.90	0.80
B	0.80	0.75	0.70	0.60
C	0.90	0.85	0.80	0.70
D	1.00	1.00	0.95	0.85

MANURE HANDLED AS A LIQUID

HSG	Fs x % Area / 100 =		Wtd Fs
B	0.8	50	0.40
C	0.9	50	0.45
			0.00
			0.00
			0.00
Total Weighted Fs =			**0.85**

MANURE HANDLED AS A SOLID

HSG	Fs x % Area / 100 =		Wtd Fs
B	0.60	50	0.30
C	0.70	50	0.35
			0.00
			0.00
			0.00
Total Weighted Fs =			**0.65**

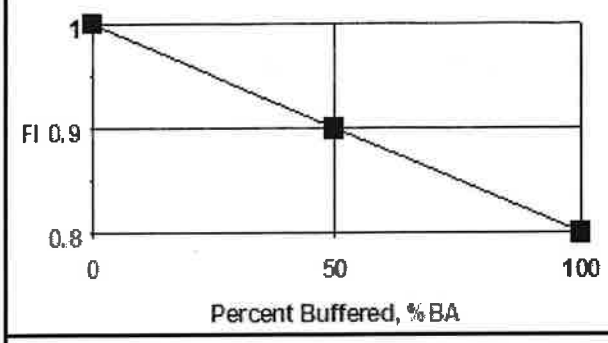
Sheet 2 of 4

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Location Factor, Fl = 0.94

Location Factor



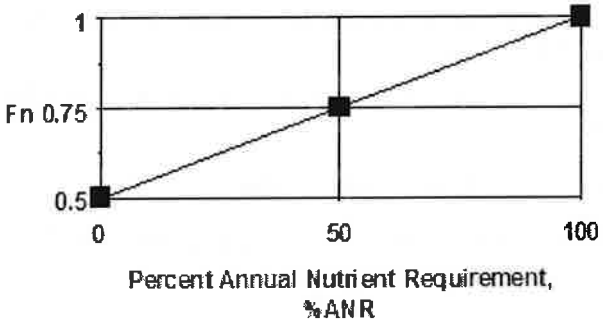
For an application area to be considered buffered there must be a 0 to 5 percent chance of flooding and the area must be at least 50 feet from water bodies, ground water sources(wells), and areas of concentrated flow. The percent buffered area(**%BA**) is determined by taking the total buffered area(TBA) and dividing it by the total land area(TLA) available for manure application.

%BA = $\frac{\text{TBA}}{\text{TLA}}$ X 100%

%BA = $\frac{38.8}{128.5}$ X 100% = 30 %

Nutrient Loading Factor, Fn = 1

Nutrient Loading Factor



In order for the Nutrient Loading Factor, Fn to be less than 1, the Location Factor, Fl must be 0.95 or less.

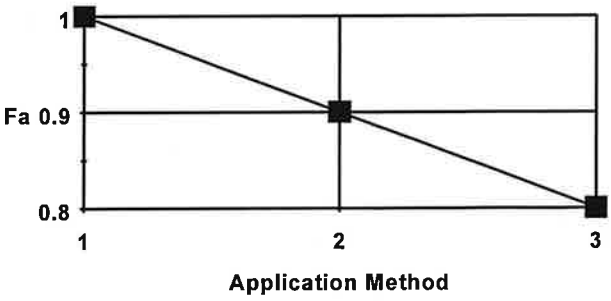
The percent of annual nutrient requirement(**%ANR**) is determined by taking the total nutrients applied(TNA) annually and dividing it by the total nutrient requirements(TNR) of all of the crops grown.

%ANR = $\frac{\text{TNA}}{\text{TNR}}$ X 100%

%ANR = $\frac{80{,}002}{66{,}905}$ X 100% = 120 %

Application Method Factor: **Fa_{LIQUID} = 0.9** **Fa_{SOLID} = 1.0**

Application Method Factor



Method 1 - Surface applied solid manure, no incorporation.

Method 2 - Surface applied liquid manure, no incorporation.

Method 3 - Injection or immediate incorporation.

Sheet 3 of 4

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Adjusted Storage Period: ASP_{LIQUID} = 158 Days **ASP_{SOLID} = 134 Days**

ALLOWS FOR THE POTENTIAL NEED

ASP = SPb X Fm X Fs X Fl X Fn X Fa

ASP_{LIQUID} = 274 X 0.8 X 0.85 X 0.94 X 1.0 X 0.9

ASP_{SOLID} = 274 X 0.8 X 0.65 X 0.94 X 1.0 X 1.0

Adjusted earliest Day of Year for application, E_a = ASP - (365 - L)

$E_{a\ LIQUID}$ = 158 - (365 - 243) = 36

$E_{a\ SOLID}$ = 134 - (365 - 243) = 12

Storage Period: SP_{LIQUID} = 158 Days **SP_{SOLID} = 154 Days**

The storage period must span the seasonal flooding conditions. The storage period must also span frozen ground and snow conditions where the land slope exceeds 5% and a buffer strip of less than 100 feet exists next to open water courses that affect the application area-

a. Enter **L** from Sheet 1 and determine the Day of Year L_f when seasonal frozen ground, snow or flooding conditions are first anticipated for the application area-

L = 243 Days **L_f = 335 Days**

If L_f comes before L then $L_{sp} = L_f$

If L_f comes after L or there is no seasonal frozen ground, snow or flooding then L_{sp} = L

L_{sp} = 243 Days

b. Determine the Day of Year E_f when seasonal frozen ground, snow or flooded conditions are no longer anticipated for the application area-

E_f = 32 Days

If E_f comes after E_a then $E_{sp} = E_f$

If E_f comes before E_a or there is no seasonal frozen ground, snow or flooding then $E_{sp} = E_a$

$E_{sp\ LIQUID}$ = 36 Days **$E_{sp\ SOLID}$ = 32 Days**

c. **SP_{LIQUID}** = 365 - (L_{sp} - $E_{sp\ LIQUID}$) = 365 - (243 - 36) = 158 Days

SP_{SOLID} = 365 - (L_{sp} - $E_{sp\ SOLID}$) = 365 - (243 - 32) = 154 Days

d. **Earliest date(E_{sp}) for manure application (month-day):**

REALLY DEPENDS ON P/P. GENERALLY FEB. CAN HAVE A 2 WK WINDOW

$E_{sp\ LIQUID}$ = February 5

$E_{sp\ SOLID}$ = February 1

e. **Latest date for manure application (month-day) = August 31**

Sheet 4 of 4

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Basic Storage Period, SPb = 213 Days

Enter average monthly Evapotranspiration(**ET**) from OSU Extension Publication 8530, Oregon Crop Water Use and Irrigation Requirements, and Precipitation(**Ppt**) Data from

Climatic Station- N WILLAMETTE EXP STA

Crop - Pasture/Hay Land

Day of Year	MONTH	Crop ET, Inches	Accum Crop ET, Inches	Ppt, Inches
1-31	January	0.36	0.36	6.17
32-59	February	0.88	1.24	4.39
60-90	March	1.46	2.70	3.99
91-120	April	3.31	6.01	2.64
121-151	May	4.53	10.54	2.17
152-181	June	5.24	15.78	1.73
182-212	July	6.22	22.00	0.70
213-243	August	5.28	27.28	0.94
244-273	September	4.02	31.30	1.84
274-304	October	2.48	33.78	3.11
305-334	November	0.43	34.21	6.03
335-365	December	0.24	34.45	7.09

a. Determine last day for the month of the year when 3/4 of Annual ET is exceeded-

3/4 of Annual ET = 0.75 x 34.45 = 25.84 Inches

L = Last Day for Month Accum ET exceeds 3/4 of Annual ET

L = 243 Days

b. Determine first day for the month of the year when ET >= Ppt-

E = First Day of Month ET >= Ppt

E = 91 Days

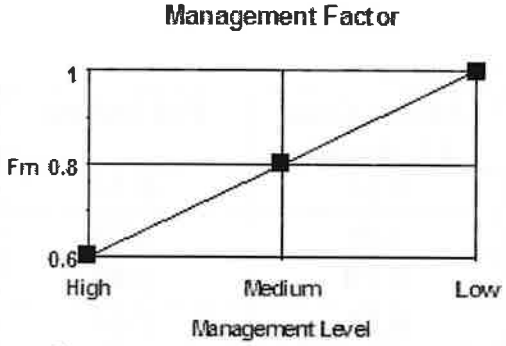
c. **SPb =** 365 - (L - E) = 365 - (243 - 91) = 213 **Days**

Sheet 1 of 4

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Management Factor, Fm = 0.8



PERMIT CONDITIONS S2C(1), S2H, S3(1), S4C(1) COULD INCREASE MGMT FACTOR

Low Level, Fm = 1.0
...The operator does not utilize a waste management plan.
...Proper operation and maintenance may not be performed.

Medium Level, Fm = 0.8
...The operator utilizes an up-to-date waste management plan.
...Manure application equipment is calibrated for nutrient applications.
...Maintains adequate soil moisture for crop growth.
...Agronomic treatments which would maximize crop nutrient uptake are not fully utilized.
...Proper operation and maintenance is planned.

High Level, Fm = 0.6
...The operator utilizes an up-to-date waste management plan.
...Soil fertility testing is performed annually.
...Manure in storage is tested for nutrient concentrations.
...Records of time, rate and location of manure applications are maintained.
...Manure application equipment is calibrated for nutrient applications.
...Irrigation water management techniques are practiced.
...Crop nutrient uptake is maximized with appropriate agronomic treatments such as residue management, conservation crop rotation, crop variety selection, prescribed grazing, and pest management.
...Proper operation and maintenance is planned.

Soils Factor: Fs_{LIQUID} = **0.85** Fs_{SOLID} = **0.65**

Soils must meet the following criteria for Fs to be less than 1.0-
...The average water holding capacity for the profile greater than 3.0 inches.
... A cation exchange capacity greater than 5 meq/100g of soil.
... Depth to a thin layer/cemented pan greater than 20 inches.
... Depth to high water table greater than 2 feet.
... A permeability greater than 0.06 inches/hr but less than 6 inches/hr.
... Cobbles less than 35% by weight in the surface layer.
... Stones and boulders less than 15% by weight in the surface layer.
... A pH greater than 5.0.
... Sodium Adsorption Ratio less than 13.
... Land slope less than 15%.

Soils Factor (Fs)

HSG	Consistency of Waste			
	Liquid	Slurry	Semi-Solid	Solid
A	1.00	0.95	0.90	0.80
B	0.80	0.75	0.70	0.60
C	0.90	0.85	0.80	0.70
D	1.00	1.00	0.95	0.85

MANURE HANDLED AS A LIQUID

HSG	Fs x % Area / 100 =		Wtd Fs
B	0.8	50	0.40
C	0.9	50	0.45
			0.00
			0.00
			0.00
Total Weighted Fs =			**0.85**

MANURE HANDLED AS A SOLID

HSG	Fs x % Area / 100 =		Wtd Fs
B	0.60	50	0.30
C	0.70	50	0.35
			0.00
			0.00
			0.00
Total Weighted Fs =			**0.65**

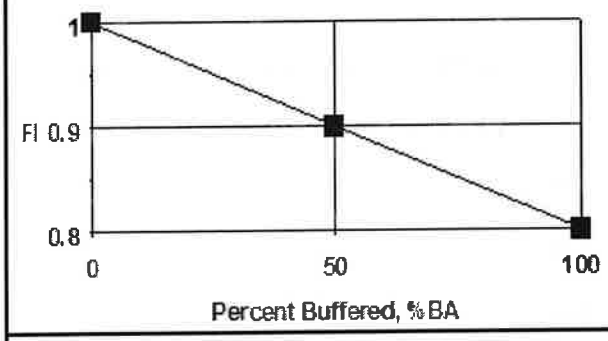
Sheet 2 of 4

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Location Factor, Fl = 0.94

Location Factor



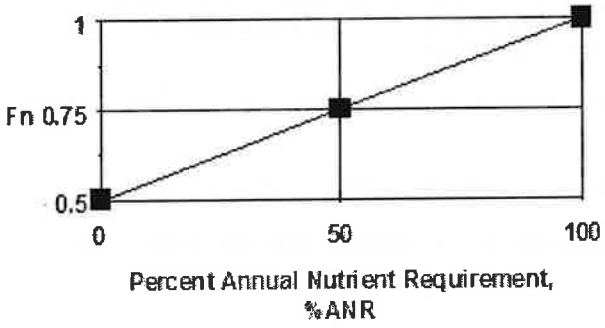
For an application area to be considered buffered there must be a 0 to 5 percent chance of flooding and the area must be at least 50 feet from water bodies, ground water sources(wells), and areas of concentrated flow. The percent buffered area(**%BA**) is determined by taking the total buffered area(TBA) and dividing it by the total land area(TLA) available for manure application.

$$\%BA = \frac{TBA}{TLA} \times 100\%$$

$$\%BA = \frac{38.8}{128.5} \times 100\% = 30\ \%$$

Nutrient Loading Factor, Fn = 1

Nutrient Loading Factor



In order for the Nutrient Loading Factor, Fn to be less than 1, the Location Factor, Fl must be 0.95 or less.

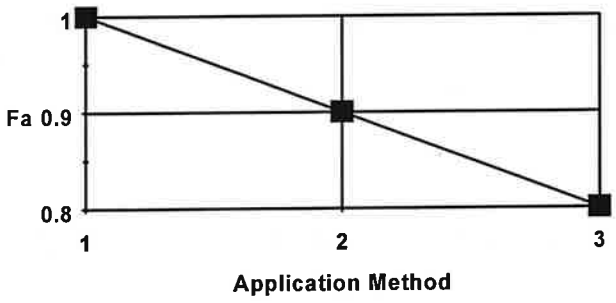
The percent of annual nutrient requirement(**%ANR**) is determined by taking the total nutrients applied(TNA) annually and dividing it by the total nutrient requirements(TNR) of all of the crops grown.

$$\%ANR = \frac{TNA}{TNR} \times 100\%$$

$$\%ANR = \frac{80{,}002}{66{,}905} \times 100\% = 120\ \%$$

Application Method Factor: Fa_{LIQUID} = **0.9** Fa_{SOLID} = **1.0**

Application Method Factor



Method 1 - Surface applied solid manure, no incorporation.

Method 2 - Surface applied liquid manure, no incorporation.

Method 3 - Injection or immediate incorporation.

Sheet 3 of 4

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Adjusted Storage Period: ASP_{LIQUID} = 115 Days **ASP_{SOLID} = 104 Days**

ASP = SPb X Fm X Fs X Fl X Fn X Fa

ASP_{LIQUID} = 213 X 0.8 X 0.8 X 0.94 X 1.0 X 0.9

ASP_{SOLID} = 213 X 0.8 X 0.65 X 0.94 X 1.0 X 1.0

Adjusted earliest Day of Year for application, **E_a** = ASP - (365 - L)

$E_{a\ LIQUID}$ = 115 - (365 - 243) = -7

$E_{a\ SOLID}$ = 104 - (365 - 243) = -18

Storage Period: SP_{LIQUID} = 158 Days **SP_{SOLID} = 154 Days**

The storage period must span the seasonal flooding conditions. The storage period must also span frozen ground and snow conditions where the land slope exceeds 5% and a buffer strip of less than 100 feet exists next to open water courses that affect the application area-

a. Enter **L** from Sheet 1 and determine the Day of Year **L_f** when seasonal frozen ground, snow or flooding conditions are first anticipated for the application area-

L = 243 Days **L_f = 335 Days**

If L_f comes before L then $L_{sp} = L_f$

If L_f comes after L or there is no seasonal frozen ground, snow or flooding then L_{sp} = L

L_{sp} = 243 Days

b. Determine the Day of Year **E_f** when seasonal frozen ground, snow or flooded conditions are no longer anticipated for the application area-

E_f = 32 Days

If E_f comes after E_a then $E_{sp} = E_f$

If E_f comes before E_a or there is no seasonal frozen ground, snow or flooding then $E_{sp} = E_a$

$E_{sp\ LIQUID}$ = 32 Days **$E_{sp\ SOLID}$ = 32 Days**

c. **SP_{LIQUID}** = 365 - (L_{sp} - $E_{sp\ LIQUID}$) = 365 - (243 - 32) = 154 Days

SP_{SOLID} = 365 - (L_{sp} - $E_{sp\ SOLID}$) = 365 - (243 - 32) = 154 Days

d. **Earliest date(E_{sp}) for manure application (month-day):**

$E_{sp\ LIQUID}$ = February 1

$E_{sp\ SOLID}$ = February 1

e. **Latest date for manure application (month-day) = October 31**

Sheet 4 of 4

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Worksheet OR10A-7- Waste storage period determination

Day of Year Calendar

Day of month	Month Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	287	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29		88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

INVENTORY, PRODUCTION AND STORAGE FACILITIES DESCRIPITON

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET
Version H&Rv2.4

11/2/2005
STATE: OREGON

CLIENT: Wil-View Farms Dairy
ASSISTED BY: Bruce Wilson CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

ANIMAL INVENTORY

Type of Animal	Number of Animals	Average Weight (lbs.)	Animal Units (1,000 lb.)	Milk Production in Pounds/Cow/Day= 60						Manure CF/D/AU	Annual	
				Nutrient Production (lbs./day/1000 lb. Animal Unit)			(lbs./day)				Days Confined	Days Grazed
				N	P	K	N	P	K			
MILKER	150	1,300	195.0	0.53	0.09	0.30	103.59	17.55	58.53	1.47	205	160
MILKER (DRY)	20	1,400	28.0	0.36	0.05	0.23	10.08	1.40	6.44	1.10	136	229
HEIFERS (12-24 Months)	100	750	75.0	0.31	0.04	0.24	23.25	3.00	18.00	1.30	136	229
CALVES (1-12 Months)	50	300	15.0	0.31	0.04	0.24	4.65	0.60	3.60	1.30	365	0
BULL	50	400	20.0	0.31	0.11	0.24	6.2	2.20	4.80	0.95	365	0
Totals/Averages-	370	830	333.0	0.44	0.07	0.27	147.8	24.8	91.4	1.4		

GRAZING PERIOD

Type of Animal	Percent of Month and Number of Animals Grazing												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AU-YR.
MILKER	70%	35%	0%	0%	0%	0%	70%	70%	70%	70%	70%	70%	
	150	150	150	150	150	150	150	150	150	150	150	150	1,024
MILKER (DRY)	100%	50%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	
	20	20	20	20	20	20	20	20	20	20	20	20	210
HEIFERS (12-24 Months)	100%	50%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	
	100	100	100	100	100	100	100	100	100	100	100	100	563
CALVES (1-12 Months)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	50	50	50	50	50	50	50	50	50	50	50	50	0
BULL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	50	50	50	50	50	50	50	50	50	50	50	50	0
													0
													0
													0
													0
													0
Total AUM's Available>	0	0	0	0	0	0	0	0	0	0	0	0	0
Total AUM's Needed>>>	240	120	0	0	0	0	240	240	240	240	240	240	1,796
Total AUM's>>>>>>>>>>	-240	-120	0	0	0	0	-240	-240	-240	-240	-240	-240	-1,796

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version H&Rv2.4

11/2/2005
STATE: OREGON

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ASSISTED BY: Bruce Wilson
CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

WEATHER STATION

N WILLAMETTE EXP STA

Month	25Yr-24Hr Monthly Average in Inches Precipitation	4.00 Evaporation	Lot Runoff Factors as a Percent of Monthly Precipitation Paved	 Unpaved
October	3.13	1.71	100%	15%
November	6.08	0.76	100%	20%
December	7.13	0.43	100%	15%
January	6.23	0.48	100%	20%
February	4.38	0.81	100%	15%
March	3.91	1.57	100%	10%
April	2.71	2.39	100%	10%
May	2.18	3.74	100%	10%
June	1.73	4.33	100%	10%
July	0.67	5.40	100%	0%
August	0.96	4.93	100%	10%
September	1.81	3.36	100%	15%
Annual	40.92	29.91		

AREAS CONTRIBUTING RUNOFF TO LIQUID STORAGE FACILITY

Description of Runoff Area	Area in SF
Paved Lot Area >>> Is paved lot scraped daily? (Y/N) YES	21,000
Unpaved Lot Area >>	0
Roof Area >>>	0
Surface Area of Silage Storage Facility>>>>>>>>>>>>>>>>>>>>>>>>>>>>> Does Silage Seepage Drain to Storage Facility? (Y/N) YES	4,500
Total Runoff Area Contributing to Liquid Storage Facility>>>>>>>>>>>>>>>	25,500

WATER USE THAT ENTERS LIQUID STORAGE FACILITY

Type of Water Use	Number of Animals	Number of Washes per Day	Gallons of Water Used per Wash-Day	Total Water Use per Day, Gallons	Total Water Use per Day, Cubic Feet
Animal Washwater	150.0	2	0.33	99	13.2
Equipment Wash		1	50.00	50	6.7
Flushwater		0		0	0.0
Miscellaneous		2	150.00	300	40.1
Total>>>				449	60.0

CROP DATA

Field Number	Acres	Crop	Condition	Yield Units	Target Yield	Nutrients Removed in Pounds per Acre Nitrogen N	 Phosphorous P_2O_5	 Potassium K_2O
6	42.0	Corn, Silage(AH)	As Harvested	Ton	20.00	154	80	184
6	42.0	Ryegrass Haylage	As Harvested	Ton	8.00	200	73	205
3,4,5,7,8	80.2	Hay/Pasture Mix 14% Protein	50% DM	Ton	4.00	179	49	137
Off-Farm								

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
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ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

BEDDING VOLUME

Type of Animal	Type of Bedding Facility	Bedding Material	Unit Weight Lbs/CF	Amount Needed Lbs/Day/AU	Volume CF/Day/AU	Total Volume CF/Day	Total Weight Lbs/Day
MILKER	Free Stall	Paper Pulp	**4.00**	**1.50**	**0.40**	78	293
MILKER (DRY)	Loose Housing	Loose Straw	**2.50**	**2.50**	**1.00**	28	70
HEIFERS (12-24 Months)	Loose Housing	Loose Straw	**2.50**	**2.50**	**1.00**	75	188
CALVES (1-12 Months)	Confined	Sawdust	**12.00**	**1.00**	**0.09**	1	15
BULL	Loose Housing	Loose Straw	**2.50**	**2.50**	**1.00**	20	50

SOLIDS SEPARATION FACTOR

Type of Animal	Type of Separator	Separation Factor %	Volume of Solids Separated CF/Day	Volume of Solids in Liquids CF/Day	Volume of Manure in Liquids CF/Day	Volume of Manure in Solids CF/Day	Accumulated Sludge in Storage CF/Day	Density of Separated Solids Lbs/CF	Weight of Separated Solids Lbs/Day
MILKER	Dry Scrape System	**0%**	0	114	286	0	189	**36**	0
MILKER (DRY)	Dry Scrape System	**100%**	59	0	0	31	0	**36**	2,117
HEIFERS (12-24 Months)	Dry Scrape System	**100%**	173	0	0	98	0	**36**	6,210
CALVES (1-12 Months)	Dry Scrape System	**100%**	21	0	0	20	0	**36**	751
BULL	Dry Scrape System	**100%**	39	0	0	19	0	**36**	1,404
Total Solids>>>			291	114	286	167	189		10,481

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
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ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY VOLUMES

Month	Runoff in Cubic Feet: Roof Area Square Feet 0	Paved Slab Area Square Feet 21,000	Unpaved Lot Area Square Feet 0	Silage Pit Surface Area, SF 4,500	Facility Water Use Cubic Feet	Manure: Solids Cubic Feet	Manure: Liquids Cubic Feet	Bedding: Cubic Feet	Bedding: Pounds	Solids Separated: Cubic Feet	Solids Separated: Pounds	Solids in Liquids: Cubic Feet	Solids in Liquids: Pounds	Total Solids Cubic Feet	Total Liquids Cubic Feet
October	0	5,478	0	674	1,861	1,526	2,327	1,387	4,735	1,855	66,793	1,058	38,083	1,855	11,730
November	0	10,640	0	930	1,801	3,777	4,879	3,707	11,516	5,265	189,540	2,218	79,850	5,265	21,351
December	0	12,478	0	899	1,861	6,279	7,757	6,273	19,065	9,026	324,923	3,526	126,942	9,026	27,629
January	0	10,903	0	966	1,861	6,279	7,757	6,273	19,065	9,026	324,923	3,526	126,942	9,026	26,120
February	0	7,665	0	696	1,681	5,671	7,006	5,666	17,220	8,152	293,479	3,185	114,657	8,152	22,092
March	0	6,843	0	645	1,861	6,279	7,757	6,273	19,065	9,026	324,923	3,526	126,942	9,026	21,740
April	0	4,743	0	576	1,801	1,477	2,252	1,343	4,583	1,796	64,638	1,024	36,854	1,796	10,802
May	0	3,815	0	82	1,861	1,526	2,327	1,387	4,735	1,855	66,793	1,058	38,083	1,855	9,475
June	0	3,028	0	65	1,801	1,477	2,252	1,343	4,583	1,796	64,638	1,024	36,854	1,796	8,576
July	0	1,173	0	0	1,861	1,526	2,327	1,387	4,735	1,855	66,793	1,058	38,083	1,855	6,751
August	0	1,680	0	36	1,861	1,526	2,327	1,387	4,735	1,855	66,793	1,058	38,083	1,855	7,294
September	0	3,168	0	576	1,801	1,477	2,252	1,343	4,583	1,796	64,638	1,024	36,854	1,796	9,227
Annual	**0**	**71,610**	**0**	**6,145**	**21,910**	**38,819**	**51,222**	**37,767**	**118,620**	**53,302**	**1,918,874**	**23,284**	**838,225**	**53,302**	**182,789**

DAILY NUTRIENT PRODUCTION

Type of Animal	Pounds/Day of Nutrients from LIQUIDS: N	P_2O_5	K_2O	Pounds/Day of Nutrients from SOLIDS: N	P_2O_5	K_2O	Pounds/Day of Nutrients from GRAZING: N	P_2O_5	K_2O
MILKER	103.59	40.21	70.53	0.00	0.00	0.00	103.59	40.21	70.53
MILKER (DRY)	0.00	0.00	0.00	10.08	3.21	7.76	10.08	3.21	7.76
HEIFERS (12-24 Months)	0.00	0.00	0.00	23.25	6.87	21.69	23.25	6.87	21.69
CALVES (1-12 Months)	0.00	0.00	0.00	4.65	1.37	4.34	0.00	0.00	0.00
BULL	0.00	0.00	0.00	6.20	5.04	5.78	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version H&Rv2.4

11/2/2005
STATE: OREGON

CLIENT: **Wil-View Farms Dairy**
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ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY NUTRIENT PRODUCTION

Month	Pounds of Nutrients from LIQUIDS			Pounds of Nutrients from SOLIDS			Pounds of Nutrients from GRAZING			Pounds of Nutrients going OFF-FARM			Total Pounds of Nutrients from ALL SOURCES		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
October	963	374	656	336	199	314	3,281	1,185	2,444	0	0	0	4,581	1,758	3,413
November	2,020	784	1,375	825	344	745	1,588	573	1,182	0	0	0	4,433	1,701	3,303
December	3,211	1,246	2,187	1,370	511	1,227	0	0	0	0	0	0	4,581	1,758	3,413
January	3,211	1,246	2,187	1,370	511	1,227	0	0	0	0	0	0	4,581	1,758	3,413
February	2,900	1,126	1,975	1,237	462	1,108	0	0	0	0	0	0	4,137	1,588	3,083
March	3,211	1,246	2,187	1,370	511	1,227	0	0	0	0	0	0	4,581	1,758	3,413
April	932	362	635	326	192	304	3,175	1,147	2,365	0	0	0	4,433	1,701	3,303
May	963	374	656	336	199	314	3,281	1,185	2,444	0	0	0	4,581	1,758	3,413
June	932	362	635	326	192	304	3,175	1,147	2,365	0	0	0	4,433	1,701	3,303
July	963	374	656	336	199	314	3,281	1,185	2,444	0	0	0	4,581	1,758	3,413
August	963	374	656	336	199	314	3,281	1,185	2,444	0	0	0	4,581	1,758	3,413
September	932	362	635	326	192	304	3,175	1,147	2,365	0	0	0	4,433	1,701	3,303
Annual	**21,204**	**8,230**	**14,438**	**8,493**	**3,712**	**7,700**	**24,237**	**8,754**	**18,051**	**0**	**0**	**0**	**53,935**	**20,696**	**40,189**

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

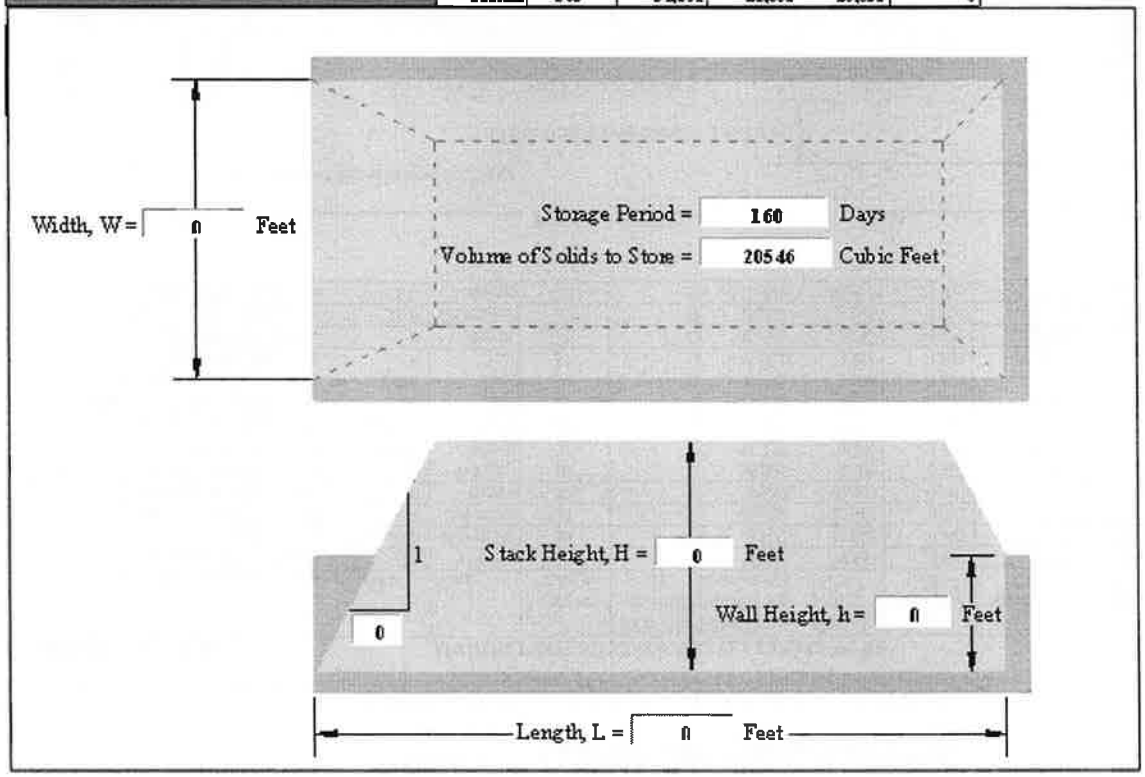
ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

SOLIDS STACKING FACILITY

Solids Storage Facility Parameters	Value
Storage Period, Days=	160
Stacking Width, W in Feet=	0
Stacking Height, H in Feet=	0.00
Wall Height, h in Feet=	0.00
Stack Side Slope (X:1)=	0.00
Existing Storage, Cubic Feet=	21,000
Surface Area of Existing Storage, SF=	0
25 Year-24 Hour Storm Runoff, CF=	0
Volume Needed, Cubic Feet=	20,546
Design Volume, Cubic Feet=	0
Is Facility Covered?	YES

MONTHLY SOLIDS VOLUME STACKED IN FACILITY

Month	Number of Days	Manure CF	Bedding CF	Solids to Store CF	Normal Runoff CF
October	31	1194	662	928	0
November	30	3080	2,186	2,633	0
December	31	5171	3,855	4,513	0
January	31	5171	3,855	4,513	0
February	28	4670	3,482	4,076	0
March	31	5171	3,855	4,513	0
April	30	1155	641	898	0
May	31	1194	662	928	0
June	30	1155	641	898	0
July	31	1194	662	928	0
August	31	1194	662	928	0
September	30	1155	641	898	0
Annual	365	31,901	21,801	26,651	0



MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

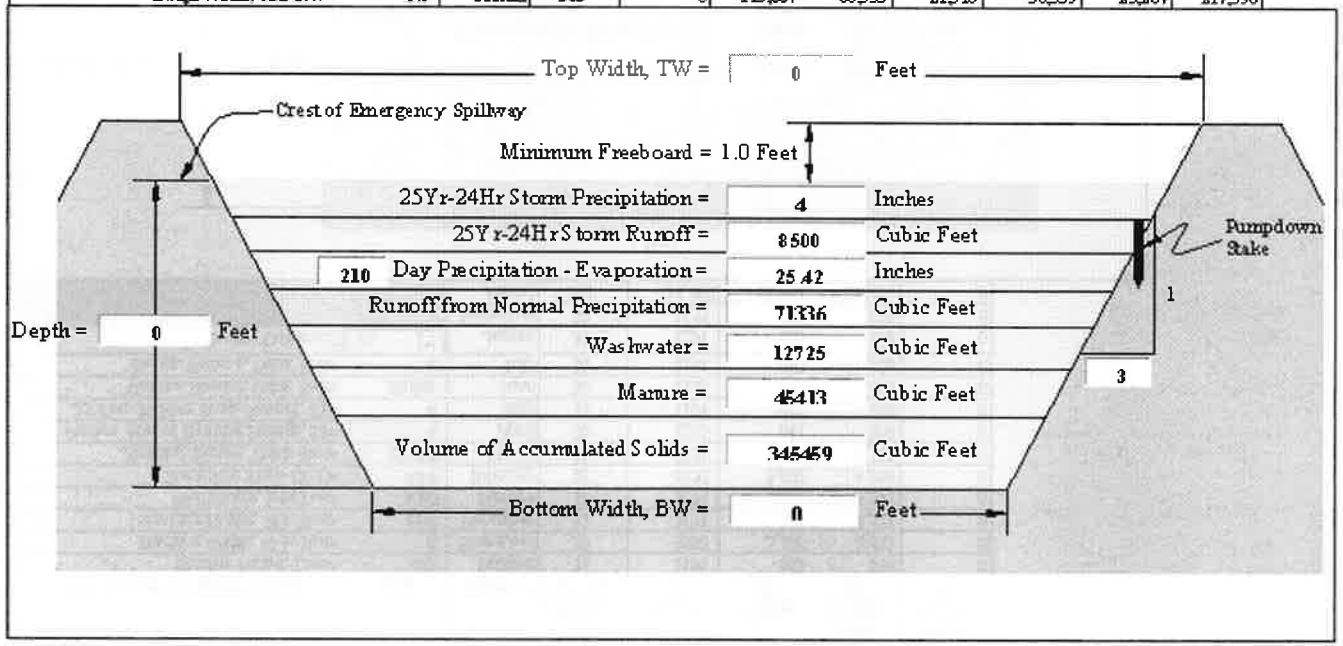
ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

WASTE STORAGE POND

Pond Parameters	Value
Storage Period, Days=	210
Side Slope (X:1)=	3.00
Bottom Width, BW, Feet=	0
Bottom Length, BL, Feet=	0
Accumulated Solids Duration, Years=	5
Existing Storage, Acre Feet=	18.60
Surface Area of Existing Storage, SF=	123,885
Minimum Soil Liner Depth, Feet=	1.00
25 Year-24 Hour Storm Runoff, CF=	8,500
Top Width, TW, Feet=	0
Top Length, TL, Feet=	0
Volume Needed, Acre Feet=	18.0
Design Volume, Acre Feet=	0.0

MONTHLY INFLOWS INTO WASTE STORAGE POND

Month	Number of Days	Rain-Evap on Pond CF	Rain-Evap on Existing Storage, CF	Normal Runoff CF	Washwater CF	Manure CF	Solids CF	Waste to Store CF
October	31	0	14,660	6,651	1,861	2,660	1,058	20,238
November	30	0	54,922	12,920	1,801	5,577	2,218	64,518
December	31	0	69,169	15,151	1,861	8,865	3,526	83,421
January	31	0	59,362	13,289	1,861	8,865	3,526	73,614
February	28	0	36,856	9,308	1,681	8,007	3,185	49,729
March	31	0	24,158	8,309	1,861	8,865	3,526	38,410
April	30	0	3,304	5,759	1,801	2,574	1,024	8,702
May	31	0	-16,105	4,633	1,861	2,660	1,058	-10,527
June	30	0	-26,842	3,676	1,801	2,574	1,024	-21,443
July	31	0	-48,831	1,424	1,861	2,660	1,058	-43,253
August	31	0	-40,985	2,040	1,861	2,660	1,058	-35,407
September	30	0	-16,002	3,846	1,801	2,574	1,024	-10,603
Annual	365	0	113,664	86,955	21,910	58,539	23,284	217,398



MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

INVENTORY, PRODUCTION AND STORAGE FACILITIES DESCRIPITON FOR MAXIMUM ANIMAL NUMBERS

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET
Version H&Rv2.4

11/2/2005
STATE: OREGON

CLIENT: Wil-View Farms Dairy- Maximum Animal Numbers
ASSISTED BY: Bruce Wilson CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

ANIMAL INVENTORY

Type of Animal	Number of Animals	Average Weight (lbs.)	Animal Units (1,000 lb.)	Milk Production in Pounds/Cow/Day= 60 Nutrient Production (lbs./day/1000 lb. Animal Unit) N	P	K	(lbs./day) N	P	K	Manure CF/D/AU	Annual Days Confined	Annual Days Grazed
MILKER	210	1,300	273.0	0.53	0.09	0.30	145.02	24.57	81.95	1.47	205	160
MILKER (DRY)	30	1,400	42.0	0.36	0.05	0.23	15.12	2.10	9.66	1.10	136	229
HEIFERS (12-24 Months)	160	750	120.0	0.31	0.04	0.24	37.20	4.80	28.80	1.30	136	229
CALVES (1-12 Months)	80	300	24.0	0.31	0.04	0.24	7.44	0.96	5.76	1.30	365	0
BULL	50	400	20.0	0.31	0.11	0.24	6.2	2.20	4.80	0.95	365	0
Totals/Averages-	530	830	479.0	0.44	0.07	0.27	211.0	34.6	131.0	1.4		

GRAZING PERIOD

Type of Animal	Percent of Month and Number of Animals Grazing OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AU-YR.
MILKER	70%	35%	0%	0%	0%	0%	70%	70%	70%	70%	70%	70%	
	210	210	210	210	210	210	210	210	210	210	210	210	1,433
MILKER (DRY)	100%	50%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	
	30	30	30	30	30	30	30	30	30	30	30	30	315
HEIFERS (12-24 Months)	100%	50%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	
	160	160	160	160	160	160	160	160	160	160	160	160	900
CALVES (1-12 Months)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	80	80	80	80	80	80	80	80	80	80	80	80	0
BULL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	50	50	50	50	50	50	50	50	50	50	50	50	0
													0
													0
													0
													0
													0
Total AUM's Available>	0	0	0	0	0	0	0	0	0	0	0	0	0
Total AUM's Needed>>>	353	177	0	0	0	0	353	353	353	353	353	353	2,648
Total AUM's>>>>>>>>>>	-353	-177	0	0	0	0	-353	-353	-353	-353	-353	-353	-2,648

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version H&Rv2.4

11/2/2005
STATE: OREGON

CLIENT: Wil-View Farms Dairy- Maximum Animal Numbers
ASSISTED BY: Bruce Wilson CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

WEATHER STATION: N WILLAMETTE EXP STA

Month	25Yr-24Hr	4.00	Lot Runoff Factors as a Percent of Monthly Precipitation	
	Monthly Average in Inches			
	Precipitation	Evaporation	Paved	Unpaved
October	3.13	1.71	100%	15%
November	6.08	0.76	100%	20%
December	7.13	0.43	100%	15%
January	6.23	0.48	100%	20%
February	4.38	0.81	100%	15%
March	3.91	1.57	100%	10%
April	2.71	2.39	100%	10%
May	2.18	3.74	100%	10%
June	1.73	4.33	100%	10%
July	0.67	5.40	100%	0%
August	0.96	4.93	100%	10%
September	1.81	3.36	100%	15%
Annual	40.92	29.91		

AREAS CONTRIBUTING RUNOFF TO LIQUID STORAGE FACILITY

Description of Runoff Area	Area in SF
Paved Lot Area >> Is paved lot scraped daily? (Y/N) YES	21,000
Unpaved Lot Area >>>	0
Roof Area >>>	0
Surface Area of Silage Storage Facility>>>>>>>>>>>>>>>>>>>>>>>>>>>>>> Does Silage Seepage Drain to Storage Facility? (Y/N) YES	4,500
Total Runoff Area Contributing to Liquid Storage Facility>>>>>>>>>>>>>>>	25,500

WATER USE THAT ENTERS LIQUID STORAGE FACILITY

Type of Water Use	Number of Animals	Number of Washes per Day	Gallons of Water Used per Wash-Day	Total Water Use per Day, Gallons	Total Water Use per Day, Cubic Feet
Animal Washwater	260.0	2	0.33	172	22.9
Equipment Wash		1	50.00	50	6.7
Flushwater		0		0	0.0
Miscellaneous		2	150.00	300	40.1
Total>>>				522	69.7

CROP DATA

Field Number	Acres	Crop	Condition	Yield Units	Target Yield	Nutrients Removed in Pounds per Acre: Nitrogen N	Phosphorous P_2O_5	Potassium K_2O
6	42.0	Corn, Silage(AH)	As Harvested	Ton	20.00	154	80	184
6	42.0	Ryegrass Haylage	As Harvested	Ton	8.00	200	73	205
3,4,5,7,8	80.2	Hay/Pasture Mix 14% Protein	50% DM	Ton	4.00	179	49	137
1,2	49.2	Hay/Pasture Mix 14% Protein	50% DM	Ton	4.00	179	49	137
Off-Farm								

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version H&Rv2.4

11/2/2005
STATE: OREGON

CLIENT: Wil-View Farms Dairy- Maximum Animal Numbers

ASSISTED BY: Bruce Wilson   CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

BEDDING VOLUME

Type of Animal	Type of Bedding Facility	Bedding Material	Unit Weight Lbs/CF	Amount Needed Lbs/Day/AU	Volume CF/Day/AU	Total Volume CF/Day	Total Weight Lbs/Day
MILKER	Free Stall	Paper Pulp	**4.00**	**1.50**	**0.40**	109	410
MILKER (DRY)	Loose Housing	Loose Straw	**2.50**	**2.50**	**1.00**	42	105
HEIFERS (12-24 Months)	Loose Housing	Loose Straw	**2.50**	**2.50**	**1.00**	120	300
CALVES (1-12 Months)	Confined	Sawdust	**12.00**	**1.00**	**0.09**	2	24
BULL	Loose Housing	Loose Straw	**2.50**	**2.50**	**1.00**	20	50

SOLIDS SEPARATION FACTOR

Type of Animal	Type of Separator	Separation Factor %	Volume of Solids Separated CF/Day	Volume of Solids in Liquids CF/Day	Volume of Manure in Liquids CF/Day	Volume of Manure in Solids CF/Day	Accumulated Sludge in Storage CF/Day	Density of Separated Solids Lbs/CF	Weight of Separated Solids Lbs/Day
MILKER	Dry Scrape System	**0%**	0	159	400	0	265	**36**	0
MILKER (DRY)	Dry Scrape System	**100%**	88	0	0	46	0	**36**	3,175
HEIFERS (12-24 Months)	Dry Scrape System	**100%**	276	0	0	156	0	**36**	9,936
CALVES (1-12 Months)	Dry Scrape System	**100%**	33	0	0	31	0	**36**	1,201
BULL	Dry Scrape System	**100%**	39	0	0	19	0	**36**	1,404
Total Solids>>			437	159	400	252	265		15,716

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version H&Rv2.4

11/2/2005
STATE: OREGON

CLIENT: **Wil-View Farms Dairy- Maximum Animal Numbers**
ASSISTED BY: **Bruce Wilson** CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY VOLUMES

Month	Runoff in Cubic Feet: Roof Area Square Feet 0	Paved Slab Area Square Feet 21,000	Unpaved Lot Area Square Feet 0	Silage Pit Surface Area, SF 4,500	Facility Water Use Cubic Feet	Manure: Solids Cubic Feet	Manure: Liquids Cubic Feet	Bedding: Cubic Feet	Bedding: Pounds	Solids Separated: Cubic Feet	Solids Separated: Pounds	Solids in Liquids: Cubic Feet	Solids in Liquids: Pounds	Total Solids Cubic Feet	Total Liquids Cubic Feet
October	0	5,478	0	893	2,162	2,022	3,258	1,703	6,102	2,243	80,754	1,481	53,316	2,243	13,736
November	0	10,640	0	1,138	2,092	5,515	6,831	5,224	16,280	7,634	274,817	3,105	111,791	7,634	25,043
December	0	12,478	0	1,118	2,162	9,376	10,860	9,094	27,544	13,533	487,201	4,937	177,718	13,533	33,105
January	0	10,903	0	1,184	2,162	9,376	10,860	9,094	27,544	13,533	487,201	4,937	177,718	13,533	31,596
February	0	7,665	0	893	1,953	8,468	9,809	8,214	24,878	12,224	440,052	4,459	160,520	12,224	27,381
March	0	6,843	0	863	2,162	9,376	10,860	9,094	27,544	13,533	487,201	4,937	177,718	13,533	27,216
April	0	4,743	0	783	2,092	1,956	3,153	1,648	5,906	2,171	78,149	1,433	51,596	2,171	12,775
May	0	3,815	0	82	2,162	2,022	3,258	1,703	6,102	2,243	80,754	1,481	53,316	2,243	11,263
June	0	3,028	0	65	2,092	1,956	3,153	1,648	5,906	2,171	78,149	1,433	51,596	2,171	10,341
July	0	1,173	0	0	2,162	2,022	3,258	1,703	6,102	2,243	80,754	1,481	53,316	2,243	8,539
August	0	1,680	0	36	2,162	2,022	3,258	1,703	6,102	2,243	80,754	1,481	53,316	2,243	9,082
September	0	3,168	0	784	2,092	1,956	3,153	1,648	5,906	2,171	78,149	1,433	51,596	2,171	11,200
Annual	**0**	**71,610**	**0**	**7,839**	**25,452**	**56,067**	**71,711**	**52,474**	**165,915**	**75,943**	**2,733,934**	**32,598**	**1,173,515**	**75,943**	**221,276**

DAILY NUTRIENT PRODUCTION

Type of Animal	Pounds/Day of Nutrients from LIQUIDS: N	P_2O_5	K_2O	Pounds/Day of Nutrients from SOLIDS: N	P_2O_5	K_2O	Pounds/Day of Nutrients from GRAZING: N	P_2O_5	K_2O
MILKER	145.02	56.29	98.75	0.00	0.00	0.00	145.02	56.29	98.75
MILKER (DRY)	0.00	0.00	0.00	15.12	4.81	11.64	15.12	4.81	11.64
HEIFERS (12-24 Months)	0.00	0.00	0.00	37.20	11.00	34.70	37.20	11.00	34.70
CALVES (1-12 Months)	0.00	0.00	0.00	7.44	2.20	6.94	0.00	0.00	0.00
BULL	0.00	0.00	0.00	6.20	5.04	5.78	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version H&Rv2.4

11/2/2005
STATE: OREGON

CLIENT: **Wil-View Farms Dairy- Maximum Animal Numbers**
ASSISTED BY: **Bruce Wilson** CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY NUTRIENT PRODUCTION

Month	Pounds of Nutrients from LIQUIDS			Pounds of Nutrients from SOLIDS			Pounds of Nutrients from GRAZING			Pounds of Nutrients going OFF-FARM			Total Pounds of Nutrients from ALL SOURCES		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
October	1,349	523	918	423	224	394	4,769	1,712	3,580	0	0	0	6,540	2,459	4,892
November	2,828	1,098	1,926	1,194	454	1,077	2,308	828	1,732	0	0	0	6,329	2,380	4,735
December	4,496	1,745	3,061	2,045	714	1,831	0	0	0	0	0	0	6,540	2,459	4,892
January	4,496	1,745	3,061	2,045	714	1,831	0	0	0	0	0	0	6,540	2,459	4,892
February	4,061	1,576	2,765	1,847	645	1,654	0	0	0	0	0	0	5,907	2,221	4,419
March	4,496	1,745	3,061	2,045	714	1,831	0	0	0	0	0	0	6,540	2,459	4,892
April	1,305	507	889	409	217	382	4,615	1,656	3,464	0	0	0	6,329	2,380	4,735
May	1,349	523	918	423	224	394	4,769	1,712	3,580	0	0	0	6,540	2,459	4,892
June	1,305	507	889	409	217	382	4,615	1,656	3,464	0	0	0	6,329	2,380	4,735
July	1,349	523	918	423	224	394	4,769	1,712	3,580	0	0	0	6,540	2,459	4,892
August	1,349	523	918	423	224	394	4,769	1,712	3,580	0	0	0	6,540	2,459	4,892
September	1,305	507	889	409	217	382	4,615	1,656	3,464	0	0	0	6,329	2,380	4,735
Annual	**29,686**	**11,523**	**20,214**	**12,094**	**4,792**	**10,947**	**35,228**	**12,643**	**26,442**	**0**	**0**	**0**	**77,008**	**28,958**	**57,603**

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

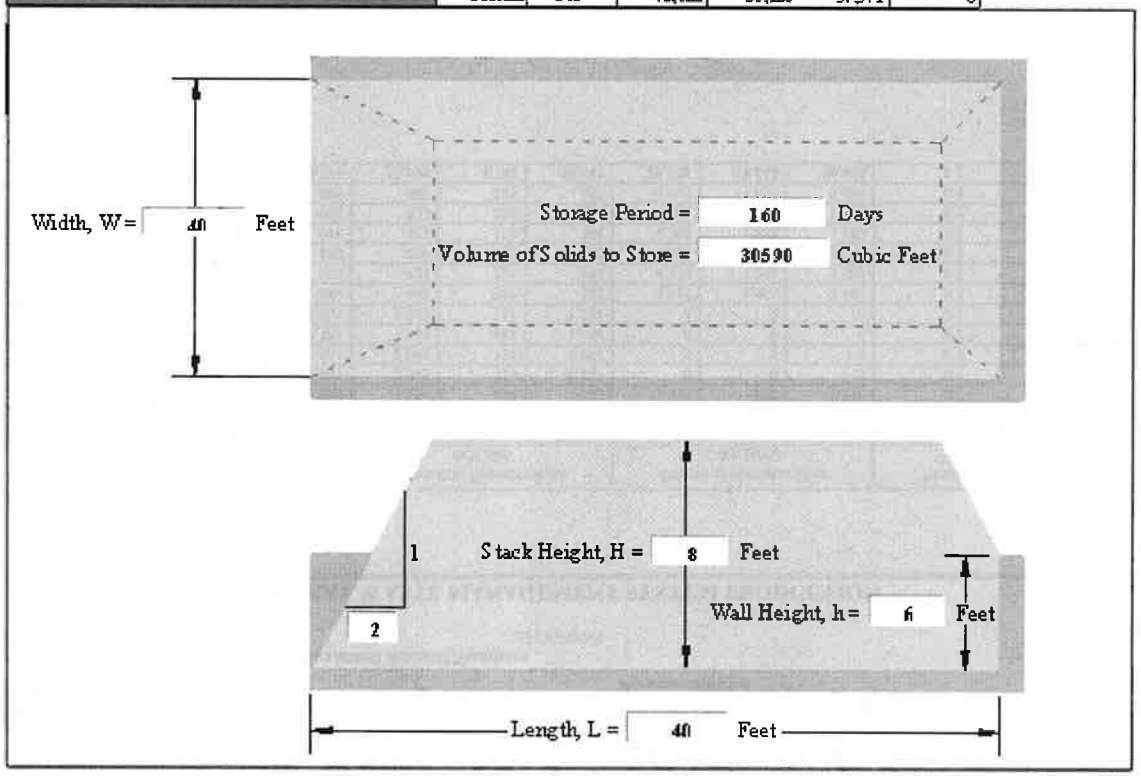
ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

SOLIDS STACKING FACILITY

Solids Storage Facility Parameters	Value
Storage Period, Days=	160
Stacking Width, W in Feet=	40
Stacking Height, H in Feet=	8.00
Wall Height, h in Feet=	6.00
Stack Side Slope (X:1)=	2.00
Existing Storage, Cubic Feet=	21,000
Surface Area of Existing Storage, SF=	0
25 Year-24 Hour Storm Runoff, CF=	0
Volume Needed, Cubic Feet=	30,590
Design Volume, Cubic Feet=	9,898
Is Facility Covered?	Yes

MONTHLY SOLIDS VOLUME STACKED IN FACILITY

Month	Number of Days	Manure CF	Bedding CF	Solids to Store CF	Normal Runoff CF
October	31	1556	687	1,122	0
November	30	4539	3,095	3,817	0
December	31	7824	5,709	6,767	0
January	31	7824	5,709	6,767	0
February	28	7067	5,156	6,112	0
March	31	7824	5,709	6,767	0
April	30	1506	665	1,085	0
May	31	1556	687	1,122	0
June	30	1506	665	1,085	0
July	31	1556	687	1,122	0
August	31	1556	687	1,122	0
September	30	1506	665	1,085	0
Annual	365	45,822	30,120	37,971	0



MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

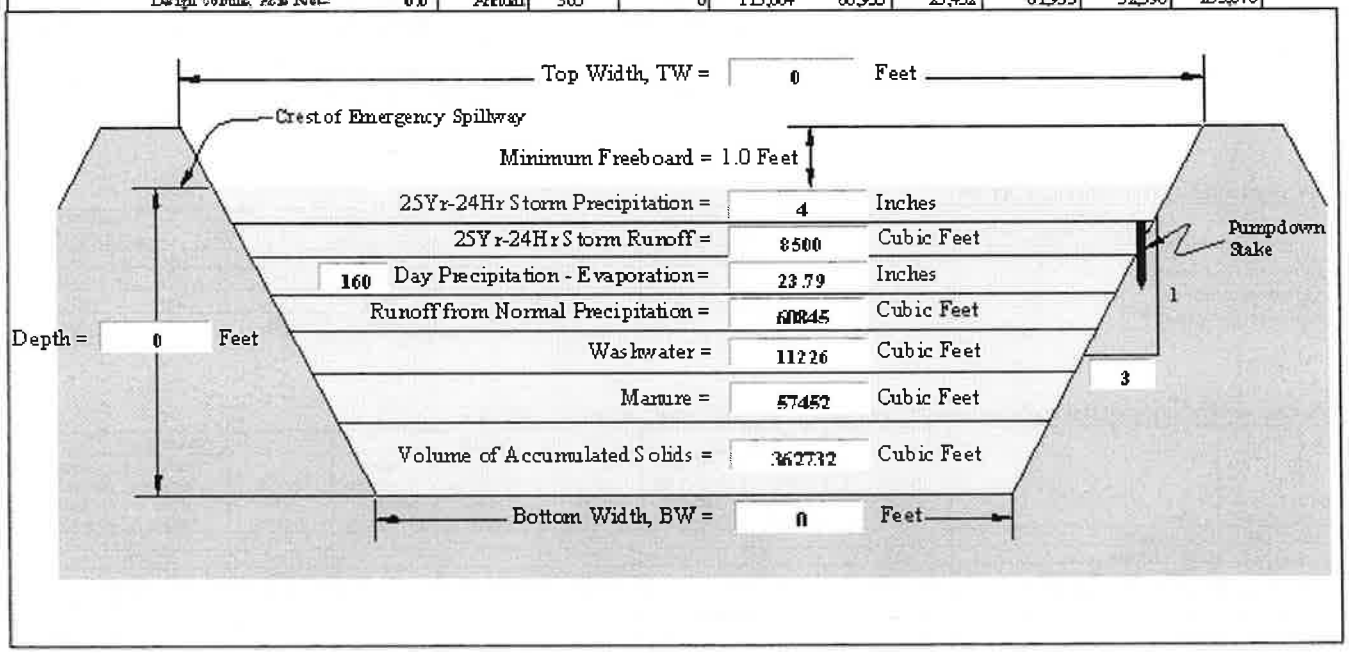
ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

WASTE STORAGE POND

Pond Parameters	Value
Storage Period, Days=	160
Side Slope (X:1)=	3.00
Bottom Width, BW, Feet=	0
Bottom Length, BL, Feet=	0
Accumulated Solids Duration, Years=	4
Existing Storage, Acre Feet=	18.60
Surface Area of Existing Storage, SF=	123,885
Minimum Soil Liner Depth, Feet=	1.00
25 Year-24 Hour Storm Runoff, CF=	8,500
Top Width, TW, Feet=	0
Top Length, TL, Feet=	0
Volume Needed, Acre Feet=	18.0
Design Volume, Acre Feet=	0.0

MONTHLY INFLOWS INTO WASTE STORAGE POND

Month	Number of Days	Rain-Evap on Pond CF	Rain-Evap on Existing Storage, CF	Normal Runoff CF	Washwater CF	Manure CF	Solids CF	Waste to Store CF
October	31	0	14,660	6,651	2,162	3,723	1,481	22,026
November	30	0	54,922	12,920	2,092	7,807	3,105	67,927
December	31	0	69,169	15,151	2,162	12,411	4,937	88,679
January	31	0	59,362	13,239	2,162	12,411	4,937	78,871
February	28	0	36,856	9,308	1,953	11,210	4,459	54,477
March	31	0	24,158	8,309	2,162	12,411	4,937	43,667
April	30	0	3,304	5,759	2,092	3,603	1,433	10,432
May	31	0	-16,105	4,633	2,162	3,723	1,481	-8,739
June	30	0	-26,842	3,676	2,092	3,603	1,433	-19,713
July	31	0	-48,831	1,424	2,162	3,723	1,481	-41,465
August	31	0	-40,985	2,040	2,162	3,723	1,481	-33,619
September	30	0	-16,002	3,846	2,092	3,603	1,433	-8,873
Annual	365	0	113,664	86,955	25,452	81,955	32,598	253,670



MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET
Version H&Rv2.4

11/21/2005
STATE: OREGON

CLIENT: **Wil-View Farms Dairy- Maximum Animal Numbers**
ASSISTED BY: **Bruce Wilson**
CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

NUTRIENTS AVAILABLE AFTER STORAGE

Nutrient Source	Type of Operation: Dairy / Type of Storage Facility	Pounds of Nutrients Available			Percent Nutrients Retained After Storage			Pounds of Nutrients Retained After Storage		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Liquids	Storage Pond (>50%) Dilution	29,686	11,523	20,214	34%	65%	80%	10,131	7,490	16,171
Solids	Solids Storage Facility (Roofed)	12,094	4,792	10,947	75%	90%	90%	9,071	4,313	9,853
Grazing	NONE	35,228	12,643	26,442	100%	100%	100%	35,228	12,643	26,442

NUTRIENTS AVAILABLE AFTER APPLICATION

Nutrient Source	Type of Application System	Pounds of Nutrients Available			Percent Nutrients Retained After Application			Pounds of Nutrients Retained After Application		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Liquids	Sprinkling	10,131	7,490	16,171	75%	100%	100%	7,599	7,490	16,171
Solids	Broadcast (Incorporated 7 or more days after application)	9,071	4,313	9,853	70%	100%	100%	6,349	4,313	9,853
Grazing	Grazing	35,228	12,643	26,442	85%	100%	100%	29,944	12,643	26,442

NUTRIENTS AVAILABLE AFTER DENITRIFICATION

Nutrient Source	Location: Between Coastal and Cascade Mountains / Soil Drainage Class	Pounds of Nutrients Available			Percent Nutrients Retained After Denitrification			Pounds of Nutrients Retained After Denitrification		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Liquids	Moderately Well Drained	7,599	7,490	16,171	87%	100%	100%	6,611	7,490	16,171
Solids	Moderately Well Drained	6,349	4,313	9,853	87%	100%	100%	5,524	4,313	9,853
Grazing	Moderately Well Drained	29,944	12,643	26,442	87%	100%	100%	26,051	12,643	26,442

PERCENT OF MANURE TO BE APPLIED TO FIELD AND UTILIZATION ACRES NEEDED BASED ON NITROGEN, N

Field Number	Acres	Crop	LIQUIDS: Percent to be Applied	LIQUIDS: Pounds of Nutrients to be Applied	LIQUIDS: Acres Needed for Utilization of Nutrients	SOLIDS: Percent to be Applied	SOLIDS: Pounds of Nutrients to be Applied	SOLIDS: Acres Needed for Utilization of Nutrients	GRAZING: Percent to be Applied	GRAZING: Pounds of Nutrients to be Applied	GRAZING: Acres Needed for Utilization of Nutrients
6	42.0	Corn, Silage(AH)	75%	4,958	32	0%	0	0	0%	0	0
6	42.0	Ryegrass Haylage	0%	0	0	0%	0	0	28%	7,297	36
3,4,5,7,8	80.2	Hay/Pasture Mix 14% Protein	15%	992	6	0%	0	0	47%	12,216	68
1,2	49.2	Hay/Pasture Mix 14% Protein	10%	661	4	0%	0	0	25%	6,538	36
0											
0											
0											
0											
0											
Off-Farm			0%	0		100%	5,524		0%	0	
		TOTALS-	100%	6,611	41	100%	5,524	0	100%	26,051	141

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET
Version H&Rv2.4

11/21/2005
STATE: OREGON

CLIENT: **Wil-View Farms Dairy- Maximum Animal Numbers**
ASSISTED BY: **Bruce Wilson**
CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

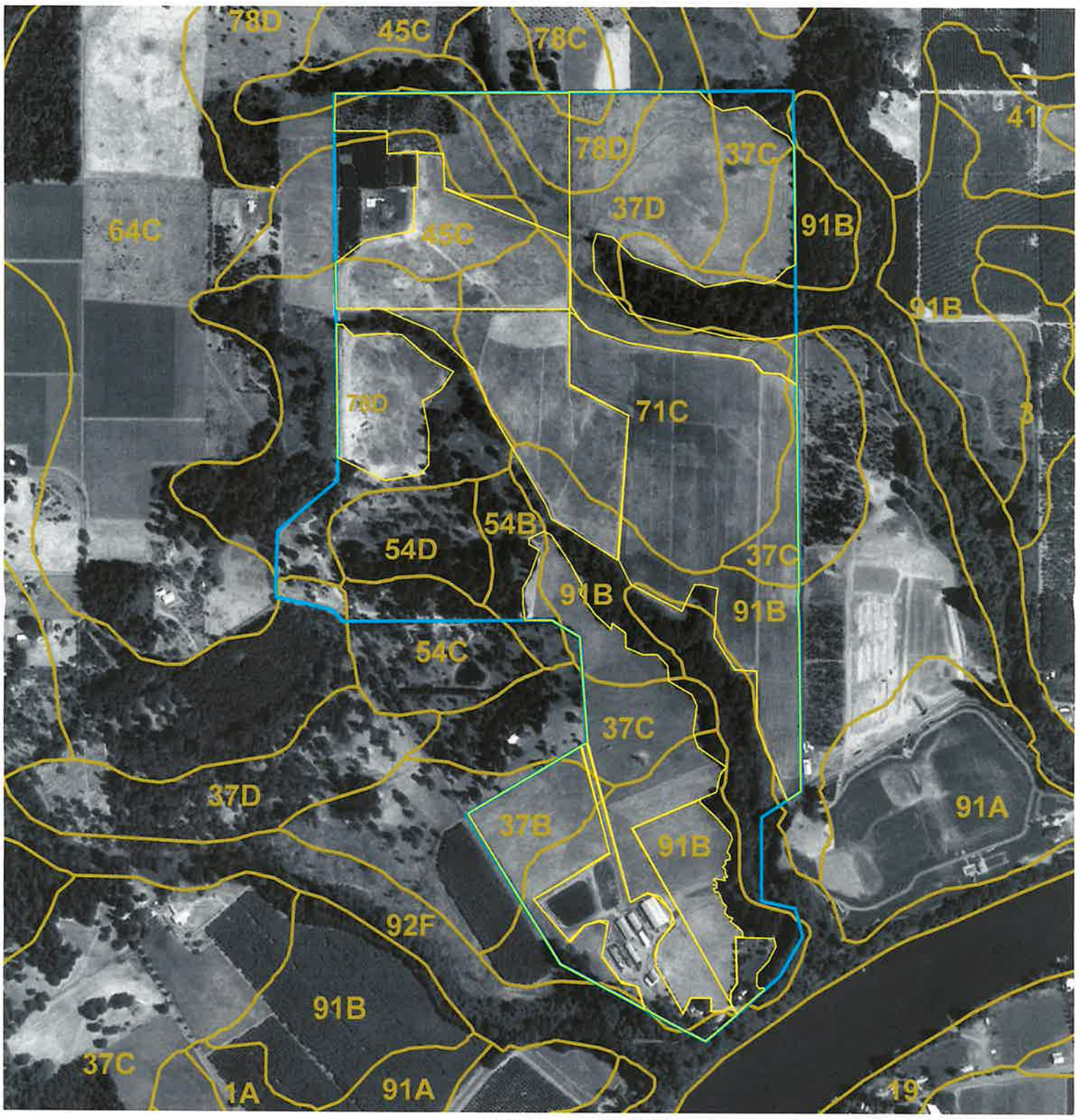
NUTRIENT BALANCE BASED ON AVAILABLE ACRES

Field Number	Acres	Crop	NUTRIENTS APPLIED - Nitrogen, N Lbs/Acre	NUTRIENTS APPLIED - Phosphorous, P_2O_5 Lbs/Acre	NUTRIENTS APPLIED - Potassium, K_2O Lbs/Acre	NUTRIENTS REMOVED - Nitrogen, N Lbs/Acre	NUTRIENTS REMOVED - Phosphorous, P_2O_5 Lbs/Acre	NUTRIENTS REMOVED - Potassium, K_2O Lbs/Acre	NUTRIENT BALANCE = Nitrogen, N Lbs/Acre	NUTRIENT BALANCE = Phosphorous, P_2O_5 Lbs/Acre	NUTRIENT BALANCE = Potassium, K_2O Lbs/Acre
6	42.0	Corn, Silage(AH)	118	134	289	154	80	184	-36	54	105
6	42.0	Ryegrass Haylage	174	84	176	200	73	205	-26	11	-29
3,4,5,7,8	80.2	Hay/Pasture Mix 14% Protein	165	88	185	179	49	137	-15	38	48
1,2	49.2	Hay/Pasture Mix 14% Protein	146	80	168	179	49	137	-33	30	31
0											
0											
0											
0											
0											
Off-Farm											

MANURE AND WASTEWATER HANDLING AND STORAGE FACILITIES

Wil-View Farms Soils Map

USDA Track 673 & 696



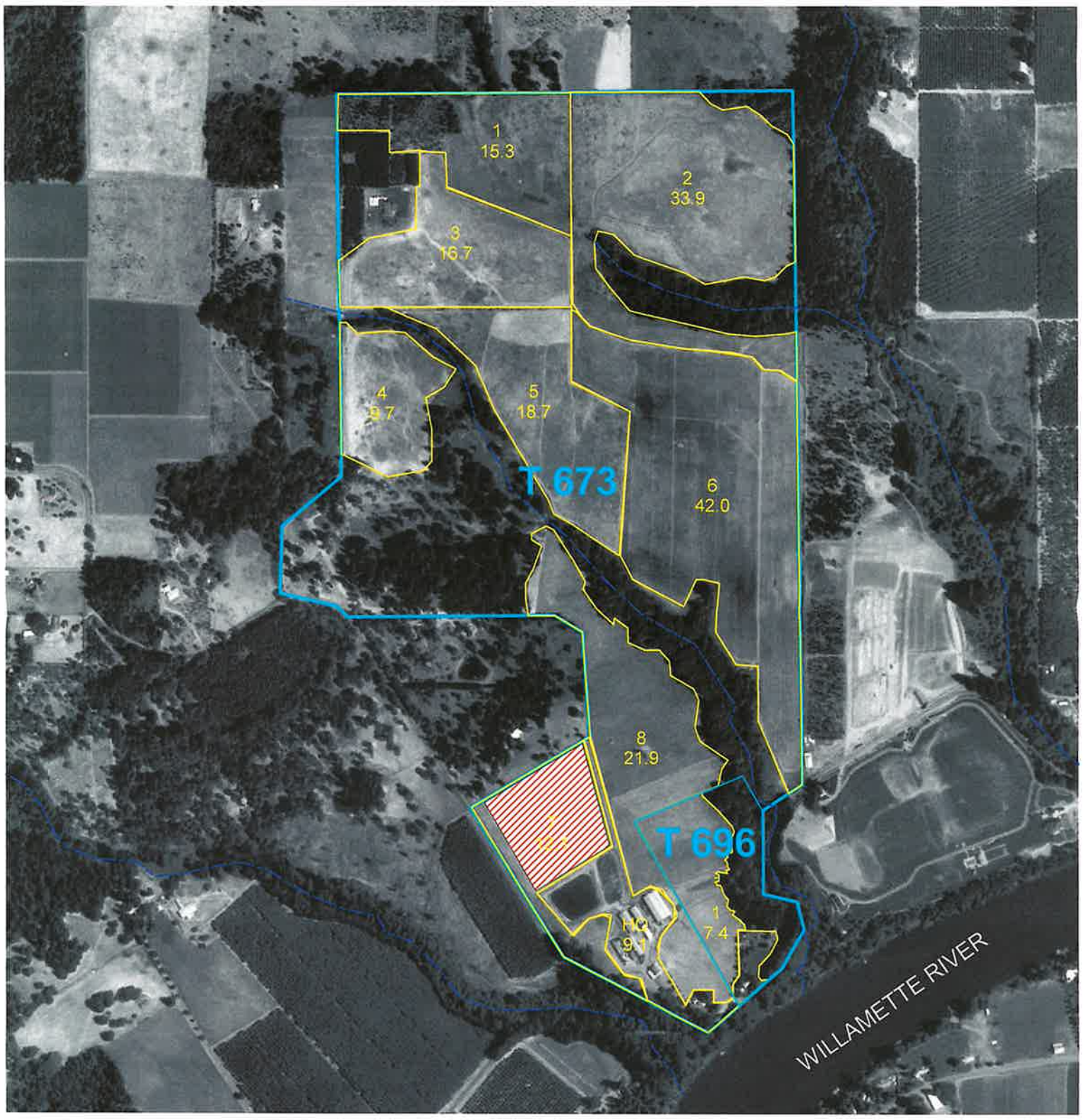
0 1000 2000 3000 Feet

N
W E
S

Wil-View Farms Plan Map

USDA Track 673 & 696

Section 18, Township 3 South, Range 1 West from the Willamette Meridian



N
W E
S

MAP LEGEND

Field Number
Acres — Field Label

Emergency Application Area

Intermittent Stream

FIELDS

LANDUSES

T 673

1,2,6	Crop Land, 91.7 Acres
3-5, 7, 8	Pasture/Hay Land, 79.1 Acres
HQ	Headquarters, 9.1 Acres

T 696

1	Pasture/Hay Land, 7.4 Acres

SCALE

0 1000 2000 3000 Feet

LAND TREATMENT PRACTICES

Soils Map Legend and Interpretations

Map Unit Legend

Clackamas County Area, Oregon

Map symbol	Map unit name
37B	Helvetia silt loam, 3 to 8 percent slopes
37C	Helvetia silt loam, 8 to 15 percent slopes
37D	Helvetia silt loam, 15 to 30 percent slopes
45C	Jory silty clay loam, 8 to 15 percent slopes
54B	Laurelwood silt loam, 3 to 8 percent slopes
71C	Quatama loam, 8 to 15 percent slopes
78D	Saum silt loam, 15 to 30 percent slopes
91B	Woodburn silt loam, 3 to 8 percent slopes
92F	Xerochrepts and Haploxerolls, very steep

Map Unit Text

Clackamas County Area, Oregon

[Only those mapunits that have entries for the selected text kinds and categories are included in this report]

Map unit: 37B - Helvetia silt loam, 3 to 8 percent slopes

Text kind/Category: Nontechnical description/SOI

The Helvetia soil is over 60 inches deep to bedrock. It is clayey, moderately well drained and occurs on terraces. A water table is present during the winter and spring. Water erosion is a potential hazard.

Map unit: 37C - Helvetia silt loam, 8 to 15 percent slopes

Text kind/Category: Nontechnical description/SOI

The Helvetia soil is over 60 inches deep to bedrock. It is clayey, moderately well drained and occurs on terraces. A water table is present during the winter and spring. Water erosion is a potential hazard.

Map unit: 37D - Helvetia silt loam, 15 to 30 percent slopes

Text kind/Category: Nontechnical description/SOI

The Helvetia soil is over 60 inches deep to bedrock. It is clayey, moderately well drained and occurs on terraces. A water table is present during the winter and spring. Water erosion is a potential hazard.

Map unit: 45C - Jory silty clay loam, 8 to 15 percent slopes

Text kind/Category: Nontechnical description/SOI

The Jory soil is over 60 inches deep to bedrock. It is clayey, well drained and occurs on mountains. Water erosion is a potential hazard.

Map unit: 54B - Laurelwood silt loam, 3 to 8 percent slopes

Text kind/Category: Nontechnical description/SOI

The Laurelwood soil is over 60 inches deep to bedrock. It is silty, well drained and occurs on mountains. Water erosion is a potential hazard.

Map unit: 71C - Quatama loam, 8 to 15 percent slopes

Text kind/Category: Nontechnical description/SOI

The Quatama soil is over 60 inches deep to bedrock. It is loamy, moderately well drained and occurs on terraces. Water erosion is a potential hazard.

LAND TREATMENT PRACTICES

Map Unit Text

Clackamas County Area, Oregon

[Only those mapunits that have entries for the selected text kinds and categories are included in this report]

Map unit: 78D - Saum silt loam, 15 to 30 percent slopes

Text kind/Category: Nontechnical description/SOI

The Saum soil is 40 to 60 inches deep to bedrock. It is clayey, well drained and occurs on mountains. Water erosion is a potential hazard.

Map unit: 91B - Woodburn silt loam, 3 to 8 percent slopes

Text kind/Category: Nontechnical description/SOI

The Woodburn soil is over 60 inches deep to bedrock. It is silty, moderately well drained and occurs on terraces. Permeability is slow. A water table is present during winter and spring. Water erosion is a potential hazard.

Map unit: 92F - Xerochrepts and Haploxerolls, very steep

Text kind/Category: Nontechnical description/SOI

Xerochrepts are 40 to 60 inches deep to bedrock. They are silty, well drained and occur on terraces. Water erosion is a potential hazard. Haploxerolls are over 60 inches deep to bedrock. They are loamy, well drained and occur on terrace scarps. Water erosion is a potential hazard.

Agricultural Disposal of Manure, Food-Processing Waste, and Sewage Sludge

Clackamas County Area, Oregon

[The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Map symbol and soil name	Pct. of map unit	Application of manure and food-processing waste		Application of sewage sludge	
		Rating class and limiting features	Value	Rating class and limiting features	Value
37B:					
Helvetia	85	Somewhat limited		Somewhat limited	
		Restricted permeability	0.3	Restricted permeability	0.22
		Too acid	0.03	Too acid	0.14
37C:					
Helvetia	85	Somewhat limited		Somewhat limited	
		Slope	0.63	Slope	0.63
		Restricted permeability	0.3	Restricted permeability	0.22
		Too acid	0.03	Too acid	0.14

LAND TREATMENT PRACTICES

Agricultural Disposal of Manure, Food-Processing Waste, and Sewage Sludge

Clackamas County Area, Oregon

[The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Map symbol and soil name	Pct. of map unit	Application of manure and food-processing waste		Application of sewage sludge	
		Rating class and limiting features	Value	Rating class and limiting features	Value
37D:					
Helvetia	85	Very limited		Very limited	
		Slope	1	Slope	1
		Restricted permeability	0.3	Restricted permeability	0.22
		Too acid	0.03	Too acid	0.14
45C:					
Jory	90	Somewhat limited		Somewhat limited	
		Slope	0.63	Too acid	0.77
		Restricted permeability	0.3	Slope	0.63
		Too acid	0.22	Restricted permeability	0.22
54B:					
Laurelwood	85	Somewhat limited		Somewhat limited	
		Restricted permeability	0.3	Too acid	0.42
		Too acid	0.11	Restricted permeability	0.22
71C:					
Quatama	85	Somewhat limited		Somewhat limited	
		Depth to saturated zone	0.86	Depth to saturated zone	0.86
		Slope	0.63	Slope	0.63
		Restricted permeability	0.3	Too acid	0.42
		Too acid	0.11	Restricted permeability	0.22

LAND TREATMENT PRACTICES

Agricultural Disposal of Manure, Food-Processing Waste, and Sewage Sludge

Clackamas County Area, Oregon

Map symbol and soil name	Pct. of map unit	Application of manure and food-processing waste		Application of sewage sludge	
		Rating class and limiting features	Value	Rating class and limiting features	Value
78D:					
Saum	80	Very limited		Very limited	
		Slope	1	Low adsorption	1
		Restricted permeability	0.3	Slope	1
		Too acid	0.11	Too acid	0.42
				Restricted permeability	0.22
91B:					
Woodburn	90	Very limited		Very limited	
		Restricted permeability	1	Restricted permeability	1
		Depth to saturated zone	0.86	Depth to saturated zone	0.86
		Too acid	0.03	Too acid	0.14
92F:					
Xerochrepts	50	Very limited		Very limited	
		Slope	1	Slope	1
		Restricted permeability	0.3	Too acid	0.67
		Too acid	0.18	Restricted permeability	0.22
Haploxerolls	35	Very limited		Very limited	
		Slope	1	Slope	1
		Too acid	0.18	Too acid	0.67
		Depth to saturated zone	0.09	Depth to saturated zone	0.09

LAND TREATMENT PRACTICES

Physical Soil Properties

Clackamas County Area, Oregon

[Entries under "Erosion Factors—T" apply to the entire profile. Entries under "Wind Erodibility Group" and "Wind Erodibility Index" apply only to the surface layer. Absence of an entry indicates that data were not estimated]

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
37B:														
Helvetia	0-14	—	—	15-25	1.10-1.30	4.00-14.00	0.19-0.21	0.0-2.9	2.0-4.0	.32	.32	5	6	48
	14-21	—	—	27-35	1.10-1.30	4.00-14.00	0.19-0.21	0.0-2.9	1.0-3.0	.32	.32			
	21-40	—	—	35-50	1.20-1.40	1.40-4.00	0.15-0.18	3.0-5.9	0.5-1.0	.37	.37			
	40-60	—	—	25-35	1.20-1.40	1.40-4.00	0.19-0.21	3.0-5.9	0.0-0.5	.43	.43			
37C:														
Helvetia	0-14	—	—	15-25	1.10-1.30	4.00-14.00	0.19-0.21	0.0-2.9	2.0-4.0	.32	.32	5	6	48
	14-21	—	—	27-35	1.10-1.30	4.00-14.00	0.19-0.21	0.0-2.9	1.0-3.0	.32	.32			
	21-40	—	—	35-50	1.20-1.40	1.40-4.00	0.15-0.18	3.0-5.9	0.5-1.0	.37	.37			
	40-60	—	—	25-35	1.20-1.40	1.40-4.00	0.19-0.21	3.0-5.9	0.0-0.5	.43	.43			
37D:														
Helvetia	0-14	—	—	15-25	1.10-1.30	4.00-14.00	0.19-0.21	0.0-2.9	2.0-4.0	.32	.32	5	6	48
	14-21	—	—	27-35	1.10-1.30	4.00-14.00	0.19-0.21	0.0-2.9	1.0-3.0	.32	.32			
	21-40	—	—	35-50	1.20-1.40	1.40-4.00	0.15-0.18	3.0-5.9	0.5-1.0	.37	.37			
	40-60	—	—	25-35	1.20-1.40	1.40-4.00	0.19-0.21	3.0-5.9	0.0-0.5	.43	.43			
45C:														
Jory	0-13	—	—	27-40	1.20-1.30	4.00-14.00	0.18-0.21	0.0-2.9	3.0-6.0	.28	.28	5	7	38
	13-60	—	—	45-60	1.30-1.50	1.40-4.00	0.15-0.17	3.0-5.9	0.5-2.0	.37	.37			
54B:														
Laurelwood	0-10	—	—	15-22	1.10-1.30	4.00-14.00	0.19-0.21	0.0-2.9	2.0-4.0	.37	.37	5	6	48
	10-18	—	—	22-30	1.15-1.30	4.00-14.00	0.19-0.21	0.0-2.9	1.0-2.0	.43	.43			
	18-46	—	—	27-35	1.20-1.30	4.00-14.00	0.19-0.21	3.0-5.9	0.5-2.0	.43	.43			
	46-60	—	—	40-50	1.30-1.50	1.40-4.00	0.15-0.17	3.0-5.9	0.0-0.5	.32	.32			
71C:														
Quatama	0-18	—	—	18-27	1.10-1.20	4.00-14.00	0.18-0.18	0.0-2.9	1.0-2.0	.32	.32	5	6	48
	18-38	—	—	25-35	1.20-1.40	1.40-4.00	0.19-0.21	0.0-2.9	0.5-1.0	.37	.37			
	38-60	—	—	12-18	1.20-1.40	1.40-4.00	0.10-0.12	0.0-2.9	0.0-0.5	.37	.37			
78D:														
Saum	0-8	—	—	20-27	1.20-1.40	4.00-14.00	0.19-0.21	0.0-2.9	2.0-4.0	.32	.32	3	6	48
	8-26	—	—	30-40	1.30-1.50	4.00-14.00	0.18-0.20	3.0-5.9	1.0-3.0	.32	.37			
	26-50	—	—	35-50	1.30-1.50	1.40-4.00	0.12-0.15	3.0-5.9	0.5-1.0	.24	.32			
	50-54	—	—	—	—	—	—	—	—	—	—			
91B:														
Woodburn	0-18	—	—	10-20	1.20-1.40	4.00-14.00	0.19-0.21	0.0-2.9	3.0-5.0	.32	.32	5	6	48
	18-38	—	—	20-35	1.20-1.40	4.00-14.00	0.19-0.21	3.0-5.9	0.5-3.0	.43	.43			
	38-60	—	—	15-30	1.30-1.50	0.42-1.40	0.19-0.21	0.0-2.9	0.0-0.5	.43	.43			
92F:														
Xerochrepts	0-8	—	—	18-27	1.10-1.40	4.00-14.00	0.16-0.21	0.0-2.9	2.0-5.0	.43	.43	5	6	48
	8-48	—	—	20-30	1.10-1.40	1.40-14.00	0.11-0.15	3.0-5.9	0.5-1.0	.28	.37			
	48-60	—	—	27-35	1.20-1.40	1.40-4.00	0.09-0.12	3.0-5.9	0.0-0.5	.20	.37			
92F:														
Haploxerolls	0-12	—	—	15-35	1.10-1.60	1.40-14.00	0.19-0.21	0.0-2.9	5.0-9.0	.32	.32	5	6	48
	12-60	—	—	15-35	1.10-1.60	1.40-14.00	0.19-0.21	3.0-5.9	0.5-2.0	.43	.43			

LAND TREATMENT PRACTICES

Water Features

Clackamas County Area, Oregon

[Depths of layers are in feet. See text for definitions of terms used in this table. Estimates of the frequency of ponding and flooding apply to the whole year rather than to individual months. Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
37B:										
Helvetia	C	—	January	3.0->6.0	3.3-5.0	—	—	None	—	None
			February	3.0->6.0	3.3-5.0	—	—	None	—	None
			March	3.0->6.0	3.3-5.0	—	—	None	—	None
			December	3.0->6.0	3.3-5.0	—	—	None	—	None
37C:										
Helvetia	C	—	January	3.0->6.0	3.3-5.0	—	—	None	—	None
			February	3.0->6.0	3.3-5.0	—	—	None	—	None
			March	3.0->6.0	3.3-5.0	—	—	None	—	None
			December	3.0->6.0	3.3-5.0	—	—	None	—	None
37D:										
Helvetia	C	—	January	3.0->6.0	3.3-5.0	—	—	None	—	None
			February	3.0->6.0	3.3-5.0	—	—	None	—	None
			March	3.0->6.0	3.3-5.0	—	—	None	—	None
			December	3.0->6.0	3.3-5.0	—	—	None	—	None
45C:										
Jory	B	—	Jan-Dec			—	—	None	—	None
54B:										
Laurelwood	B	—	Jan-Dec			—	—	None	—	None
71C:										
Quatama	C	—	January	2.0-3.0	>6.0	—	—	None	—	None
			February	2.0-3.0	>6.0	—	—	None	—	None
			March	2.0-3.0	>6.0	—	—	None	—	None
			April	2.0-3.0	>6.0	—	—	None	—	None
			December	2.0-3.0	>6.0	—	—	None	—	None
78D:										
Saum	B	—	Jan-Dec			—	—	None	—	None
91B:										
Woodburn	C	—	January	2.0-3.0	2.0-3.3	—	—	None	—	None
			February	2.0-3.0	2.0-3.3	—	—	None	—	None
			March	2.0-3.0	2.0-3.3	—	—	None	—	None
			April	2.0-3.0	2.0-3.3	—	—	None	—	None
			December	2.0-3.0	2.0-3.3	—	—	None	—	None
92F:										
Xerochrepts	C	—	February	3.0->6.0	3.3->6.0	—	—	None	—	None
			March	3.0->6.0	3.3->6.0	—	—	None	—	None
			April	3.0->6.0	3.3->6.0	—	—	None	—	None
			December	3.0->6.0	3.3->6.0	—	—	None	—	None
Haploxerolls	C	—	February	3.0-4.0	4.0-5.0	—	—	None	—	None
			March	3.0-4.0	4.0-5.0	—	—	None	—	None
			December	3.0-4.0	4.0-5.0	—	—	None	—	None

LAND TREATMENT PRACTICES

Predicted Soil Loss (Erosion) for Planned System

Farm or Tract	Field Number	Acreage	Soil Survey IDMap Unit	Soil Acreage	T Value Tons/Ac/Yr	Predicted Soil Loss Tons/Ac/Yr
McNiel T673	1	15.3	61078D	9.64	5	<1
McNiel T673	1	15.3	61037D	3.86	5	<1
McNiel T673	1	15.3	61045C	1.55	5	<1
McNiel T673	2	33.9	61037D	13.22	5	<1
McNiel T673	2	33.9	61037C	6.54	5	<1
McNiel T673	2	33.9	61071C	4.44	5	<1
McNiel T673	3	16.7	61071C	4.83	5	<1
McNiel T673	3	16.7	61078D	3.89	5	<1
McNiel T673	3	16.7	61045C	7.67	5	<1
McNiel T673	4	9.7	61078D	9.7	5	<1
McNiel T673	5	18.7	61078D	1.18	5	<1
McNiel T673	5	18.7	61071C	13.76	5	<1
McNiel T673	5	18.7	61091B	3.74	5	<1
McNiel T673	6	42	61091B	11.38	5	<1
McNiel T673	6	42	61037C	3.95	5	<1
McNiel T673	6	42	61071C	26.21	5	<1
McNiel T673	7	12.1	61037B	6.67	5	<1
McNiel T673	7	12.1	61091B	5.11	5	<1
McNiel T673	7	12.1	61037C	0.18	5	<1
McNiel T673	8	21.9	61091B	13.82	5	<1
McNiel T673	8	21.9	61037C	6.81	5	<1
McNiel T673	8	21.9	61054B	1.14	5	<1
McNiel T673	HQ	9.1	61091B	8.35	NA	NA
McNiel T673	HQ	9.1	61092F	0.48	NA	NA
McNiel T673	HQ	9.1	61037B	0.14	NA	NA
McNiel T696	1	7.4	61091B	7.4	5	<1
McNiel T696	HQ	1.5	61091B	1.5	5	<1
McNiel T696	HQ	1.5	61092F	0	5	<1

LAND TREATMENT PRACTICES

Farm Resource Setting

The landscape is generally stream floodplains, broad terraces and rolling hillsides above the streams in valleys along the Willamette River. The annual precipitation varies from 40-50 inches of which 70% falls within a 5 month period from November through March and less than 7% falls from June through August. Winds are generally moderate in the winter (15-30 mph) from the south to southwest and mild in the summer (5-15 mph) from the north to northwest. Humidity usually varies from 60 to 90 percent throughout the year except when dry east winds occur dropping the humidity to 10 to 15 percent. There is approximately 200-210 frost free days and the average annual temperature is 50 to 55 degrees Fahrenheit. Soils Vary from deep to moderately deep clays, silts and sandy loams that are poor to excessively well drained.

The headquarters facilities generally contain confined livestock feeding operations and associated structures such as home(s), barns, lots, commodity sheds, shop areas, and feed storage areas. Also included are the components of a waste management system consisting of manure and wastewater production, collection, transfer, treatment and storage facilities.

The sprinkler irrigated crop land consists mainly of corn silage, pasture and hay land grown for livestock feed. The crop, pasture and hay land fields are also used to utilize nutrients and organics in manure and wastewater from a livestock feeding operation.

Headquarters Land Use Resource Concerns

Resource Concern	Description
Water Quality, Surface Water; Nutrients & Organics	Nutrients and organics contained in manure produced from AFO are contaminating surface water
Air Quality; Undesirable Odors from Agricultural Sources	Air quality is affected by odors produced from the headquarter facilities.

Headquarters Land Use Plan of Operations

Field ID	Conservation or Best Management Practices	Amount	Existing or Planned
HQ	Access Road (Ft) (PS560) Existing or planned roadways to allow access to farm facilities and fields to perform needed management operations. Refer to Section 8 for Operation and Maintenance guidelines for existing roadways.	2,030Feet	Existing
HQ	Fence (Ft) (PS382) Fences are constructed in areas as shown on the facilities map to control the movement and access of animals and humans. Refer to Section 8 for Operation and Maintenance guidelines for existing Fences.	2,640 Feet	Existing
HQ	Heavy Use Area Protection (Ac) (PS561) Areas shown on the facilities map are stabilized with suitable materials to control soil erosion, improve air and water quality, improve aesthetics and improve animal health. Refer to Section 8 for Operation and Maintenance guidelines for existing Heavy Use Protection areas.	0.45 Acres	Existing

LAND TREATMENT PRACTICES

Field ID	Conservation or Best Management Practices	Amount	Existing or Planned
HQ	Manure Transfer (No) (PS634) Production wastewater and contaminated runoff from the milkhouse and holding area will be transferred to a 8 foot by 14 foot wide 8 foot deep reinforced concrete collection tank as shown on the facilities map.	1	Exisitng
	Wastewater will be transferred from the collection tank and slab areas to cell #1 of the waste storage pond for long term storage.	1	Existing
	A catch basin is installed near the silage storage structures to collect leachate and contaminated runoff from the solids storage slab and transfer it to cell #1 of the waste storage pond using a buried PVC pipeline.	1	Existing
	Wastewater will be transferred from the waste storage pond to the crop, pasture and hay land fields for utilization using pipelines and traveling big gun sprinklers.	1	Existing
	Solid wastes will be transferred from the production area to a solids stacking slab or off farm for utilization.	1	Existing
	Refer to Section 8 for Operation and Maintenance guidelines for existing Manure Transfer equipment and refer to Section 11 for drawings and specifications for planned Manure Transfer equipment and pipelines.		
HQ	Pipeline (Ft) (PS516) Pipelines are installed to convey water from a source to the place of use as shown on the facilities and plan maps to provide water for livestock, wildlife and human use. Refer to Section 8 for Operation and Maintenance guidelines for existing Pipelines.	830 Feet	Existing
HQ	Pumping Plant (No) (PS533) Pumping Plants shown on the facilities and plan maps are used to transfer water or waste water at a planned rate and operating pressure. Refer to Section 8 for Operation and Maintenance guidelines for existing Pumping Plants.	1	Existing
HQ	Roof Runoff Structure (No) (PS558) Gutters and downspouts are installed to collect, control, and transport rainfall from roofs. Refer to Section 8 for Operation and Maintenance guidelines for existing Roof Runoff Structures.	10	Existing
HQ	Underground Outlet (Ft) (PS620) Subsurface pipe is placed to collect and convey water from roof runoff structures to a suitable outlet. Refer to Section 8 for Operation and Maintenance guidelines for existing Underground Outlets.	400 Feet	Existing
HQ	Use Exclusion (Ac) (PS472) Access to areas shown on the facilities map will be controlled to maintain or improve the quantity and quality of natural resources or minimize liability and human health concerns. Refer to Section 8 for Operation and Maintenance guidelines for existing Use Exclusion areas.	9.1 Acres	Existing

LAND TREATMENT PRACTICES

Field ID	Conservation or Best Management Practices	Amount	Existing or Planned
HQ	Waste Storage Facility (No) (PS313) Collection tanks shown on the facilities map are used to collect manure and contaminated water from production facilities. The collection tanks vary in size and are not considered as long term storage facilities.	1- Reinforced Concrete Collection Tank	Existing
	Solids storage slab next to the silage storage areas shown on the facilities map are used for storage of solid manure removed from barns. Half of the slab area has been constructed and the other half will be completed within the next couple of years. The solids storage slabs have a capacity of 21,000 cubic feet which is estimated to provide 160 days of storage.	1- Solids Storage Slab	Planned
	The two cell waste storage pond shown on the facilities map is used for long term storage of manure and contaminated water from production facilities. The storage pond has a capacity of 18.6 acre feet which is estimated to provide 210 days of storage. Refer to Section 8 for Operation and Maintenance guidelines for existing Waste Storage Facilities.	1- 2 cell Waste Storage Pond	Existing
HQ	Water Well (No) (PS642) Wells shown on the facilities map supply water for livestock, and other uses. Refer to Section 8 for Operation and Maintenance guidelines for existing Water Wells.	1	Existing
HQ	Watering Facility (No) (PS614) Permanent and portable watering facilities provide livestock access to water while they are in barns and out on pasture. Refer to Section 8 for Operation and Maintenance guidelines for existing Watering Facilities.	10	Existing

Crop Land Use Resource Concerns

Resource Concern	Description
Soil Erosion; Sheet & Rill	Erosion from cropland fields is exceeding the allowable average annual soil loss, T.
Soil Condition; Tilth, Crusting, Infiltration, Organic Matter	Tillage operations are causing a decrease in soil tilth and organic matter.
Water Quantity, Water Mgt. Irrigated Land	Irrigation applications are excessive or inadequate to meet the crop needs.
Water Quality, Groundwater; Nutrients & Organics	Nutrients from inorganic fertilizer and manure applications are leached to groundwater.
Water Quality, Surface Water; Nutrients & Organics	Nutrients and organics are contained in runoff reaching streams and lakes.
Water Quality, Surface Water; Suspended Sediments & Turbidity	Runoff from cropland fields contains suspended sediments.
Air Quality; Airborne Chemical Drift	Wind causes chemicals from pesticide, herbicide and manure applications to drift.
Air Quality; Undesirable Odors from Agricultural Sources	Undesirable odors emanate from chemical and manure applications.
Plant Management; Nutrient Management	Nutrients applications are excessive or inadequate to meet plant needs.

LAND TREATMENT PRACTICES

Crop Land Use Plan of Operations

Field ID	Conservation or Best Management Practices	Amount	Existing or Planned
6	Access Road (Ft) (PS560) Existing or planned roadways to allow access to farm facilities and fields to perform needed management operations. Refer to Section 8 for Operation and Maintenance guidelines for existing roadways.	390 Feet	Existing
6	Cover Crop (Ac) (PS340) Grasses, legumes, forbs, or other herbaceous plants established in fields as shown on the plan map for seasonal cover to control erosion, sequester carbon in plant biomass, improve soil tilth, capture excess nutrients, suppress weeds, provide supplemental forage, improve soil moisture management and reduce particulate emissions. Refer to Section 8 for Operation and Maintenance guidelines for established Cover and Green Manure Crops.	42 Acres	Existing
6	Irr.Pipeline-High-pressure, Underground, Plastic (Ft) (PS430DD) High-pressure Underground Plastic pipe is placed in fields at the locations shown on the plan map to convey irrigation water and waste water to irrigation systems in an efficient manner to prevent conveyance losses and soil erosion. Refer to Section 8 for Operation and Maintenance guidelines for existing High-pressure Plastic Irrigation Pipelines.	1,170 Feet RISER LOCATIONS ALONG W/L	Existing
6	Irrigation System-Sprinkler (No-Ac) (PS442) A sprinkler irrigation system will be used to apply irrigation water and wastewater in an efficient manner to the fields as shown on the plan map to manage soil moisture and apply nutrients and organics to promote plant growth without causing excessive runoff and leaching. Refer to Section 8 for Operation and Maintenance guidelines for existing Sprinkler Irrigation Systems.	1- 42 Acres	Existing
6	Irrigation Water Management (Ac) (PS449) Irrigation Water Management is applied to the irrigated fields as shown on the plan map to manage soil moisture to promote the desired crop response, optimize the available water supplies, minimize irrigation induced erosion, decrease non-point source pollution of surface and groundwater sources, manage salts in the crop root zone and manage the crop micro climate. Refer to Section 8 for Operation and Maintenance guidelines for current Irrigation Water Management activities and refer to Section 11 for specifications for planned Irrigation Water Management activities.	42 Acres	Planned

LAND TREATMENT PRACTICES

Field ID	Conservation or Best Management Practices	Amount	Existing or Planned
6	Nutrient Management (Ac) (PS590) The amount, placement, source, timing of inorganic and organic nutrients and soil amendments is managed on fields shown on the plan map to prevent non-point source pollution of air, surface water and ground water resources. The nutrient application plan for 2005-2006 crop year is shown in Section 6. The plan for all fields is based on balancing for nitrogen which will cause an over application of phosphorus and potassium. It is likely that soil test phosphorus levels will increase in the future based on the current nutrient application plan and additional acreage may be needed to balance phosphorus. Refer to Section 8 for Operation and Maintenance guidelines for current Nutrient Management activities and refer to Section 11 for specifications for planned Nutrient Management activities.	42 Acres	Planned
6	Waste Utilization (Ac) (PS633) Application equipment is calibrated to apply solid and liquid organic waste at the rate needed to meet the requirements of the nutrient management practice for the crops grown. Refer to Section 8 for Operation and Maintenance guidelines for current Waste Utilization activities and refer to Section 11 for specifications for planned Waste Utilization activities.	42 Acres	Planned

Pasture/Hay Land Use Resource Concerns

Resource Concern	Description
Water Quality, Groundwater; Nutrients & Organics	Slight to Moderate potential leaching of nitrates.
Water Quality, Surface Water; Nutrients & Organics	High potential for surface runoff of nutrients.
Water Quantity, Water Mgt. Irrigated Land	Irrigation applications are excessive or inadequate to meet the crop needs.
Plant Management; Nutrient Management	Nutrients not balanced with plant needs.

Pasture/Hay Land Use Plan of Operations

Field ID	Conservation or Best Management Practices	Amount	Existing or Planned
T673-3, 4, 5, 7, 8	Access Road (Ft) (PS560) Existing or planned roadways to allow access to farm facilities and fields to perform needed management operations. Refer to Section 8 for Operation and Maintenance guidelines for existing roadways.	3,900 Feet	Existing
T673-3, 4, 5, 7, 8 T696-1	Fence (Ft) (PS382) Barriers constructed in areas as shown on the plan map to control the movement and access of animals and humans. Refer to Section 8 for Operation and Maintenance guidelines for existing Fences.	20,300 Feet 1,370 Feet	Existing Existing

LAND TREATMENT PRACTICES

Field ID	Conservation or Best Management Practices	Amount	Existing or Planned
T673-3, 4, 5, 7, 8 T696-1	Forage Harvest Management (Ac) (PS511) The timely cutting and removal of forages from the fields shown on the plan map for hay, green-chop or ensilage. Refer to Section 8 for Operation and Maintenance guidelines for established Forage Harvest Management.	79.1 Acres 7.4 Acres	Existing Existing
T673-3, 4, 5, 7, 8	Irr. Pipeline-High-Pressure, Underground, Plastic (Ft) (PS430DD) High-Pressure Underground Plastic pipe is placed in fields at the locations shown on the plan map to convey irrigation water and waste water to irrigation systems in an efficient manner to prevent conveyance losses and soil erosion. Refer to Section 8 for Operation and Maintenance guidelines for existing High-pressure Plastic Irrigation Pipelines.	5,000 Feet	Existing
T673-3, 4, 5, 7, 8 T696-1	Irrigation System- Sprinkler (No-Ac) (PS442) A sprinkler irrigation system will be used to apply irrigation water and wastewater in an efficient manner to the fields as shown on the plan map to manage soil moisture and apply nutrients and organics to promote plant growth without causing excessive runoff and leaching. Refer to Section 8 for Operation and Maintenance guidelines for existing Sprinkler Irrigation Systems.	1- 79.1 Acres 1- 7.4 Acres	Existing Existing
T673-3, 4, 5, 7, 8 T696-1	Irrigation Water Management (Ac) (PS449) Irrigation Water Management is applied to the irrigated fields as shown on the plan map to manage soil moisture to promote the desired crop response, optimize the available water supplies, minimize irrigation induced erosion, decrease non-point source pollution of surface and groundwater sources, manage salts in the crop root zone and manage the crop micro climate. Refer to Section 8 for Operation and Maintenance guidelines for current Irrigation Water Management activities and refer to Section 11 for specifications for planned Irrigation Water Management activities.	79.1 Acres 7.4 Acres	Planned Planned
T673-3, 4, 5, 7, 8 T696-1	Nutrient Management (Ac) (PS590) The amount, placement, source, timing of inorganic and organic nutrients and soil amendments is managed on fields shown on the plan map to prevent non-point source pollution of air, surface water and ground water resources. Refer to Section 8 for Operation and Maintenance guidelines for current Nutrient Management activities and refer to Section 11 for specifications for planned Nutrient Management activities.	79.1 Acres 7.4 Acres	Planned Planned
T673-3, 4, 5, 7, 8 T696-1	Pasture & Hayland Planting (Ac) (PS512) As pasture and hay land fields need renovating, adapted and compatible species, varieties, or cultivars will be established in the fields as shown on the plan map to provide forage and hay for livestock. Refer to Section 11 for specifications for Pasture and Hayland Planting.	79.1 Acres 7.4 Acres	Planned Planned

LAND TREATMENT PRACTICES

Field ID	Conservation or Best Management Practices	Amount	Existing or Planned
T673-3, 4, 5, 7, 8 T696-1	Waste Utilization (Ac) (PS633) The traveling "Big Gun" irrigators will be calibrated to apply solid and liquid organic waste at the rate needed to meet the requirements of the nutrient management practice for the crops grown. Refer to Section 8 for Operation and Maintenance guidelines for current Waste Utilization activities and refer to Section 11 for drawings and specifications for planned Waste Utilization activities.	79.1 Acres 7.4 Acres	Planned Planned
T673-3, 4, 5, 7, 8 T696-1	Watering Facility (No) (PS614) Portable watering facilities provide livestock access to water on pastured fields. Refer to Section 8 for Operation and Maintenance guidelines for existing Watering Facilities.	4 1	Existing Existing

NUTRIENT MANAGEMENT

Utilization Area Summary

Farm or Tract	Field Number	Acreage	Buffered Acreage	Spreadable Acreage	Soil Test P (ppm)	PI Risk Rating	Controlling Nutrient
McNiel T673	3	16.7	0	16.7	71	LOW	Nitrogen
McNiel T673	4	9.7	0	9.7	60	LOW	Nitrogen
McNiel T673	5	18.7	0	18.7	45	LOW	Nitrogen
McNiel T673	6	42	0	42	84	MEDIUM	Nitrogen
McNiel T673	7	12.1	0	12.1	168	MEDIUM	Nitrogen
McNiel T673	8	21.9	0	21.9	161	MEDIUM	Nitrogen
McNiel T696	1	7.4	0	7.4	161	MEDIUM	Nitrogen

Crop Type, Yield Goals, and Nutrient Utilization Rates

Farm or Tract	Field Number	Crop Name	Expected Yield/Acre (AH Basis)	Nutrient Removal (lb/Acre)		
				N	P2O5	K2O
McNiel T673	3	Hay/Pasture Mix (16% Protein)	4 Tons	205	57	157
McNiel T673	4	Hay/Pasture Mix (16% Protein)	4 Tons	205	57	157
McNiel T673	5	Hay/Pasture Mix (16% Protein)	4 Tons	205	57	157
McNiel T673	6	Corn, silage	30 Tons	231	120	275
McNiel T673	6	Hay/Pasture Mix (16% Protein)	4 Tons	205	57	157
McNiel T673	8	Hay/Pasture Mix (16% Protein)	4 Tons	205	57	157
McNiel T673	7	Hay/Pasture Mix (16% Protein)	4 Tons	205	57	157
McNiel T696	1	Hay/Pasture Mix (16% Protein)	4 Tons	205	57	157

Land Base Requirements[1, 2]

Year	Acreage Available	Acreage Required Based on Nitrogen Recommendation		Acreage Required Based on Phosphorus Removal	
		Land Required	Excess or *(Still Needed)*	Land Required	Excess or *(Still Needed)*
2006	128.5	80	48.5	153	(24.5)

1. Acreage required for Nitrogen utilization is based on estimated losses and does not account for any nutrient credits.
2. Land base requirements are based on the crop rotation described in this plan.

Manure Nutrient Analysis

Storage Name	Sample Date	% Moisture	TKN	NH4-N	Org - N	NO3-N	P205	K20	Units
Dry Pack	9/28/2005	65	9	3	6	0	4	19	lbs/Ton
Waste Storage Pond	9/28/2005	97	8	4	4	0	4	12	lbs/th gals

NUTRIENT MANAGEMENT

Soil Test Results

Farm or Tract	Field Number	Sample ID	Sample Date	OM%	P	K	Mg	Ca	Units	Soil pH	CEC
McNiel T673	3	73	7/25/2005	6.3	71	188	799	109	ppm	5.9	6.5
McNiel T673	4	74	7/25/2005	6.4	60	227	813	113	ppm	6	6.6
McNiel T673	5	75	7/25/2005	4.6	45	168	571	96	ppm	5.6	5.4
McNiel T673	6	76	5/9/2005	4.6	84	251	1123	156	ppm	5.9	9.2
McNiel T673	7	77	7/25/2005	5.9	168	291	546	110	ppm	5.4	6.2
McNiel T673	8	78	7/25/2005	5.7	161	249	772	169	ppm	5.4	8.3
McNiel T696	1	79	7/25/2005	5.7	161	249	772	169	ppm	5.4	8.3

Estimated Phosphorus Concentrations in Soils after 2, 5 and 10 Years Based on Bray P1 Extraction and Planned Nutrient Management

Farm or Tract	Field Number	P At Start	Units	2 Years	5 Years	10 Years
McNiel T673	3	71	ppm	74.1	78.75	86.5
McNiel T673	4	60	ppm	62.4	66	72
McNiel T673	5	45	ppm	49.5	56.25	67.5
McNiel T673	6	84	ppm	89.6	98	112
McNiel T673	7	168	ppm	170.4	174	180
McNiel T673	8	161	ppm	163.4	167	173
McNiel T696	1	161	ppm	166.1	173.75	186.5

Note: This plan will have to be revised when phosphorus concentrations in soils and phosphorus applications cause a change in the Phosphorus Index site vulnerability rating.

NUTRIENT MANAGEMENT

Phosphorus Index

The Phosphorus Index for Oregon was developed by a nutrient management advisory group comprised of members from the Natural Resources Conservation Service in Oregon and Washington, Oregon State University, Washington State University, and agricultural industry.

The Phosphorus Index is a field-level assessment tool designed to evaluate the relative potential for off-site movement of phosphorus from the landscape. The purpose of the Phosphorus Index is to provide field personnel, watershed planners, and land managers with a tool to assess various soils, landforms, and management practices for potential risk of phosphorus movement into surface waters. Conservation planners can use the Phosphorus Index to develop alternatives that include management and conservation practices that will reduce the potential for phosphorus transport to surface waters.

Phosphorus Concerns in the Environment

Eutrophication is the process of enrichment of water with nutrients, mainly phosphorus and nitrogen, which results in excessive growth of algae and nuisance aquatic plants. The movement of phosphorus in runoff and eroded sediment from agricultural land to surface water can accelerate eutrophication. Phosphorus is the limiting nutrient in most fresh water systems. The eutrophic condition and excessive aquatic plant growth cause depletion of oxygen in water due to heavy oxygen demand by microorganisms as they decompose organic material. The pH of water also increases as algae and other aquatic plants consume carbon dioxide.

Eutrophication impairs water use for fisheries, wildlife, recreation, agriculture, industry, and drinking due to excessive growth of algae and other aquatic plants. Some blue-green algae can form compounds that are toxic to livestock, humans, and other animals. Accelerated eutrophication is often associated with increases in water pH, causing an increase in ammonia concentrations, which can be harmful to fish and other aquatic animals.

Phosphorus Movement in the Landscape

Phosphorus movement in runoff occurs in sediment-bound and dissolved forms. Sediment P is attached to mineral and organic particles and is transported during erosion events. In general, sediment P contributes about 60 to 90 percent of the P transported in runoff from most cultivated land. Dissolved P makes up the largest portion of the total P in runoff from non-cultivated lands such as pastures, hayland, forests, and cropland using no-till practices. Most sediment P is not readily available for algae and plant uptake because it is chemically bound with mineral (particularly iron, aluminum, and calcium) and organic compounds. Sediment P can however represent a long-term source of P for algae and aquatic plant uptake from the water body. Most dissolved P is immediately available for aquatic plant uptake.

Phosphorus Movement Factors

The main factors influencing P movement can be separated into two main categories: **transport and source factors.** The following factors are considered in the Phosphorus Index for Oregon.

Transport factors:

- Soil erosion (sheet and rill, wind)
- Irrigation-induced erosion
- Runoff class
- Flooding frequency
- Distance to surface waters / buffer width
- Subsurface drainage

Source Factors:

- Soil test P concentration
- Commercial P fertilizer application rate
- Commercial P fertilizer application method
- Organic P source application rate
- Organic P source application method

Each factor is assigned a ***Phosphorus Loss Rating*** of ***None, Low, Medium, High, or Very High*** based on the relative risk of phosphorus transport to surface waters. In addition, each factor is assigned a ***Factor Weight*** ranging from 0.25 to 1.50, based on the relative contribution of that factor to P transport.

Separate Phosphorus Indices were developed for Western and Eastern Oregon. Differences in cropping systems, tillage practices, irrigation systems, climatic factors, and soil phosphorus testing methods across the state made it necessary to have separate indices.

Descriptions of Phosphorus Index Factors

Transport Factors-

Soil Erosion

Soil Erosion – tons/ac/yr (RUSLE)	tons/ac/yr (Score)	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)

This factor includes both sheet and rill and wind erosion. Irrigation-induced erosion is addressed in other factors. Sheet and rill erosion is the detachment of soil particles by raindrop impact, surface runoff from rainfall, and snowmelt runoff on frozen or thawing soil. Wind erosion is the detachment and transport of soil particles by wind forces. Sheet and rill erosion rates are estimated with the Revised Universal Soil Loss Equation (RUSLE). Wind erosion rates are estimated using the Wind Erosion Equation (WEQ). These soil loss models predict long-term average erosion rates, over the entire crop rotation, in tons of soil loss per acre per year. They do not predict sediment transport and delivery to a water body. The prediction models are used in the Phosphorus Index to quantify the movement of soil, thus potential for sediment and attached phosphorus transport on a slope or unsheltered distance toward a water body.

Soil Erosion from Sprinkler Irrigation

Soil Erosion from Sprinkler Irrigation	Criteria (Score)	No sprinkler irrigation (0)	Application rate < infiltration rate *OR* No visible runoff at field borders (0.75)	Application rate = infiltration rate OR Little to no visible runoff at field borders (1.5)	Application rate > infiltration rate OR Visible runoff at field borders (3.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (6.0)

This factor is evaluated by comparing the application rate of the sprinkler irrigation system (inches of water per hour) with the infiltration rate of the soil. A visual assessment of runoff and soil erosion caused by irrigation water is also conducted to assign a *Phosphorus Loss Rating* to this factor.

Runoff Class

Runoff Class	Criteria (Score)	Negligible (0)	Very low or low (1.0)	Medium (2.0)	High (4.0)	(8.0)

The *runoff class* is determined from the *hydrologic group* assigned to the soil map units in a field, and the average slope gradient. *Hydrologic groups* are group of soils having similar runoff potential under similar

storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonally high water table, intake rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. (National Soil Survey Handbook, Part 618.35).

Flooding Frequency Class

Flooding Frequency Class	Criteria (Score)	None or very rare (0)	Rare (0.75)	Occasional (1.5)	Frequent (3.0)	Very Frequent (6.0)

Flooding is the temporary covering of the soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources. Floodwaters can carry both sediment-bound and dissolved P into surface waters. Estimates of flooding frequency are based on the interpretation of soil properties and other evidence gathered during soil survey fieldwork. Flooding frequency is defined as the number of times flooding occurs over a period of time and is expressed as a class.

Distance to Perennial Surface waters / Buffer Widths

Distance to Perennial Surface Waters / Buffer Widths	Criteria (Score)	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.75)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.5)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (3.0)	< 100 feet AND No buffer next to surface waters (6.0)

This factor considers the flow distance from the edge of the field to the closest perennial surface water, which may include streams, lakes, and those irrigation and drainage ditches that contain water year around. It also considers the presence and width of a vegetated buffer adjacent to that surface water. The closer the edge of the field is to surface water, the higher the potential risk of P transport to that water.

Vegetated buffers are effective in trapping sediment-bound P in runoff water. They are less effective in reducing dissolved P transport. Dissolved P can flow through a buffer and enter surface water. The wider the vegetated buffer, the more effective it will be in reducing total P transport to surface water. Vegetated buffers that are commonly used adjacent to perennial water include filter strips (NRCS Standard 393) and riparian forest buffers (NRCS Standard 391).

Subsurface Drainage

Subsurface Drainage	Criteria (Score)	No Tile Drains (0)	Tile drains present Soil Test P (Bray P1) < 60 ppm (0.5)	Tile drains present Soil Test P (Bray P1) 61 - 140 ppm (1.0)	Tile drains present Soil Test P (Bray P1) 141- 190 ppm (2.0)	Tile drains present Soil Test P (Bray P1) > 190 ppm (4.0)

Recent research has shown that P can leach through the soil profile, and the risk of leaching is directly related to the soil test P concentration in the soil. The higher the P concentration, the greater the potential for leaching. When subsurface drainage is present, such as perforated pipe tile drains, dissolved and sediment-bound P can enter the drains and be directly transported to surface water at the drain outlet. This factor therefore considers whether tile drains are present in the field, and the soil test P concentration.

Source Factors-

NUTRIENT MANAGEMENT

Soil Test P

Soil Test P – ppm (Bray P1)	(Score)	Soil Test P – 40 x 0.10 = (_____) Assign 0 points if Soil Test P < 40 ppm

A soil sample from the site is necessary to assess the level of "available P" in the surface layer of the soil. Available P is the level customarily reported in a soil test analysis by commercial soil test laboratories. The soil test level for "available P" does not ascertain the total P in the soil. It does however, give an indication of the amount of total P that may be present because of the general relationship between the forms of P (organic, adsorbed, and labile) and the dissolved P available for crop uptake. The higher the soil test P level, the greater the risk of P transport to surface waters.

The depth at which soil samples are collected for available P analysis should be determined from the fertilizer or nutrient management guides for the crops being grown on the site. These guides are available from Oregon State University or Washington State University Cooperative Extension Services. Sampling depth is normally 0 to 6 inches or 0 to 12 inches for cultivated crops, and generally corresponds to typical depth of primary tillage. For established pastures that have not been cultivated for many years, a sample depth of 0 to 3 inches may be appropriate because P tends to be concentrated near the surface when the soil is not cultivated.

In eastern Oregon, soil test P levels should be determined using the Olsen (sodium bicarbonate) extraction method. In western Oregon, the Bray P1 extraction method should be used.

P Fertilizer Application Rate

Commercial P Fertilizer Application Rate	(Score)	lbs/ac P_2O_5 x 0.02 = (_____)

The P fertilizer application rate is the amount of commercial phosphate fertilizer (P_2O_5), in pounds per acre per year, which is applied to the soil. This factor does not include phosphorus from organic sources. The higher the application rate, the greater the risk of P transport to surface waters.

Commercial P Fertilizer Application Method

Commercial P Fertilizer Application Method	Criteria	None Applied	Injected / banded deeper than 2 inches OR Incorporated within 5 days of application from March through September	Incorporated within 5 days of application from October through February OR Surface applied March through August	Incorporated more than 5 days after application OR Surface applied September through October	Surface applied November through February
	(Score)	(0)	(1.0)	(2.0)	(4.0)	(8.0)

The manner in which P fertilizer is applied to the soil, and the length of time that fertilizer remains on the soil surface will affect potential P movement. Banding or incorporating P fertilizer into the soil reduces the risk of P transport. P fertilizer that is surface applied, and not incorporated into the soil, has a higher risk of transport to surface water.

The time of year that P fertilizer is applied also affects the risk of P movement. P fertilizer that is applied during the winter and early spring in Western Oregon, when heavy or prolonged precipitation events are likely to occur, creates a higher risk of P transport than applications made from mid-spring to early fall. In Eastern Oregon, there is a greater risk of P transport when fertilizer is surface applied and not incorporated prior to irrigation or winter precipitation.

NUTRIENT MANAGEMENT

Organic P Source Application Rate

Organic P Source Application Rate	(Score)	lbs/ac P_2O_5 x 0.02 = (_____)

The organic P source application rate is the amount of phosphate (P_2O_5) contained in organic material that is applied to the soil, in pounds per acre per year. An analysis of the organic material is desirable to determine the phosphorus content. When an analysis of the organic material is not available, values from the Animal Waste Management Field Handbook can be used. The higher the application rate, the greater the risk of P transport to surface waters.

Organic P Source Application Method

Organic P Source Application Method	Criteria	None Applied	Injected deeper than 2 inches OR Incorporated within 5 days of application from March through September	Incorporated within 5 days of application from October through February OR Surface applied March through August	Incorporated more than 5 days after application OR Surface applied September through October	Surface applied November through February
	(Score)	(0)	(1.0)	(2.0)	(4.0)	(8.0)

The manner in which organic P material is applied to the soil, and the length of time it remains on the soil surface will affect potential P movement. Injecting or incorporating organic P sources into the soil reduces the risk of P transport. Organic P material that is surface applied, and not incorporated into the soil, has a higher risk of transport to surface water.

The time of year that organic P is applied also affects the risk of P movement. Organic P that is applied during the winter and early spring in western Oregon, when heavy or prolonged precipitation events are likely to occur, creates a higher risk of P transport than applications made from mid-spring to early fall. In Eastern Oregon, there is a greater risk of P transport when organic material is surface applied and not incorporated prior to irrigation or winter precipitation.

Oregon Phosphorus Index Rating and Interpretation

P Index rating	Interpretation	Recommended Nutrient Limitation
PI Score<13	Low potential for P movement from this site given current management practices and site characteristics. There is a low probability of an adverse impact to surface waters from P losses on this site. Soil test P and P losses are likely to increase in future due to N-based nutrient management from animal manure.	Nitrogen
PI Score 13-25	Medium potential for P movement from this site given current management practices and site characteristics. Practices should be introduced to reduce P losses by surface runoff, subsurface flow, and erosion. Soil test P and P losses are likely to increase in future due to N-based nutrient management from animal manure.	Nitrogen
PI Score 25.1-50	High potential for P movement from this site given current management practices and site characteristics. All practicable management practices to reduce P losses through surface runoff, subsurface flow, or erosion should be implemented.	Phosphorus
PI Score >50	Very high potential for P movement from this site given current management practices and site characteristics. Active remediation techniques should be implemented in an effort to reduce the P loss potential from this site.	No manure

NUTRIENT MANAGEMENT

Phosphorus Index – Western Oregon

	<<<<<<<<<<<<<<Transport Factors>>>>>>>>>>>>>>							<<<<<<<<<<Source Factors>>>>>>>>>>						
Field ID Field Number Tract Number	Soil Ero-sion	Sprink-ler Irriga-tion	Surf Irriga-tion	Runoff Class	Flood Freq-uency	Dist to Water	Sub-surf Drain-age	Soil Test P	Inorg App Rate	Inorg App Meth	Org App Rate	Org App Meth	Total Rating Value	**Site Vulner-ability Class**
3 McNiel T673	1.5	0.75	0	4	0	0	0	3.1	0	0	0.14	3	12.49	**LOW**
4 McNiel T673	1.5	0.75	0	4	0	0	0	2	0	0	0	0	8.25	**LOW**
5 McNiel T673	1.5	0.75	0	4	0	0	0	0.5	0	0	0.42	3	10.17	**LOW**
6 McNiel T673	1.5	0.75	0	4	0	0	0	4.4	0	0	1.64	3	15.29	**MEDIUM**
7 McNiel T673	1.5	0.75	0	4	0	0	0	12.8	0	0	0	0	19.05	**MEDIUM**
8 McNiel T673	1.5	0.75	0	4	0	0	0	12.1	0	0	0	0	18.35	**MEDIUM**
1 McNiel T696	1.5	0.75	0	4	0	0	0	12.1	0	0	0.54	3	21.89	**MEDIUM**

Planned Manure Exports

Export Date	Exported To	Quantity	Units	TKN	NH4-N	Org-N	NO3-N	P205	K20
5/10/2006	Composting Facility	20	Ton	9	3	6	0	4	19
6/14/2006	Composting Facility	20	Ton	9	3	6	0	4	19
7/12/2006	Composting Facility	20	Ton	9	3	6	0	4	19
8/16/2006	Composting Facility	200	Ton	9	3	6	0	4	19
9/20/2006	Composting Facility	200	Ton	9	3	6	0	4	19

NUTRIENT MANAGEMENT

Nutrient Application Plan

Notes and Assumptions:
- **Outlets to tile drained fields must be controlled if liquid manure is applied.**

Tract Number	Allocation Date	Field Name	Spreadable Acres	Nutrient Source	Application Equipment	Amount Applied per Field	Pounds N Lb/Acre	Pounds P2O5 Lb/Acre	Pounds K2O Lb/Acre
McNiel T673	4/19/2006	6	42	Waste Storage Pond	Big gun irrigation system	924 th gals or 0.81 inches	109	88	264
McNiel T673	5/10/2006	6	42	Waste Storage Pond	Big gun irrigation system	924 th gals or 0.81 inches	109	88	264
McNiel T673	10/11/2006	6	42	Waste Storage Pond	Big gun irrigation system	504 th gals or 0.44 inches	60	48	144
Pasture Credits-							85	42	86
Total Nutrients Applied to Field 6-							**363**	**266**	**758**
McNiel T696	5/17/2006	1	7.4	Waste Storage Pond	Big gun irrigation system	50.69 th gals or 0.25 inches	34	27	82
Pasture Credits-							166	81	167
Total Nutrients Applied to Field 1-							**200**	**108**	**249**

NUTRIENT MANAGEMENT

Nutrient Utilization Worksheet

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET
Version H&Rv2.4

11/21/2005
STATE: OREGON

CLIENT: Wil-View Farms Dairy
ASSISTED BY: Bruce Wilson

CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

NUTRIENTS AVAILABLE AFTER STORAGE

Nutrient Source	Type of Operation: Dairy / Type of Storage Facility	Pounds of Nutrients Available N	Pounds of Nutrients Available P_2O_5	Pounds of Nutrients Available K_2O	Percent Nutrients Retained After Storage N	Percent Nutrients Retained After Storage P_2O_5	Percent Nutrients Retained After Storage K_2O	Pounds of Nutrients Retained After Storage N	Pounds of Nutrients Retained After Storage P_2O_5	Pounds of Nutrients Retained After Storage K_2O
Liquids	Storage Pond (>50%) Dilution	21,204	8,230	14,438	31%	65%	80%	6,471	5,350	11,551
Solids	Solids Storage Facility (Roofed)	8,493	3,712	7,700	75%	90%	90%	6,370	3,341	6,930
Grazing	NONE	24,237	8,754	18,051	100%	100%	100%	24,237	8,754	18,051

NUTRIENTS AVAILABLE AFTER APPLICATION

Nutrient Source	Type of Application System	Pounds of Nutrients Available N	Pounds of Nutrients Available P_2O_5	Pounds of Nutrients Available K_2O	Percent Nutrients Retained After Application N	Percent Nutrients Retained After Application P_2O_5	Percent Nutrients Retained After Application K_2O	Pounds of Nutrients Retained After Application N	Pounds of Nutrients Retained After Application P_2O_5	Pounds of Nutrients Retained After Application K_2O
Liquids	Sprinkling	6,471	5,350	11,551	75%	100%	100%	4,853	5,350	11,551
Solids	Broadcast (Incorporated 7 or more days after application)	6,370	3,341	6,930	70%	100%	100%	4,459	3,341	6,930
Grazing	Grazing	24,237	8,754	18,051	85%	100%	100%	20,602	8,754	18,051

NUTRIENTS AVAILABLE AFTER DENITRIFICATION

Nutrient Source	Location: Between Coastal and Cascade Mountains / Soil Drainage Class	Pounds of Nutrients Available N	Pounds of Nutrients Available P_2O_5	Pounds of Nutrients Available K_2O	Percent Nutrients Retained After Denitrification N	Percent Nutrients Retained After Denitrification P_2O_5	Percent Nutrients Retained After Denitrification K_2O	Pounds of Nutrients Retained After Denitrification N	Pounds of Nutrients Retained After Denitrification P_2O_5	Pounds of Nutrients Retained After Denitrification K_2O
Liquids	Moderately Well Drained	4,853	5,350	11,551	87%	100%	100%	4,222	5,350	11,551
Solids	Moderately Well Drained	4,459	3,341	6,930	87%	100%	100%	3,879	3,341	6,930
Grazing	Moderately Well Drained	20,602	8,754	18,051	87%	100%	100%	17,924	8,754	18,051

PERCENT OF MANURE TO BE APPLIED TO FIELD AND UTILIZATION ACRES NEEDED BASED ON NITROGEN, N

Field Number	Acres	Crop	LIQUIDS Percent to be Applied	LIQUIDS Pounds of Nutrients to be Applied	LIQUIDS Acres Needed for Utilization of Nutrients	SOLIDS Percent to be Applied	SOLIDS Pounds of Nutrients to be Applied	SOLIDS Acres Needed for Utilization of Nutrients	GRAZING Percent to be Applied	GRAZING Pounds of Nutrients to be Applied	GRAZING Acres Needed for Utilization of Nutrients
6	42.0	Corn, Silage(AH)	100%	4,222	27	0%	0	0	0%	0	0
6	42.0	Ryegrass Haylage	0%	0	0	0%	0	0	20%	3,585	18
3,4,5,7,8	80.2	Hay/Pasture Mix 14% Protein	0%	0	0	0%	0	0	80%	14,339	80
0											
0											
0											
0											
0											
0											
Off-Farm			0%	0		100%	3,879		0%	0	
		TOTALS-	100%	4,222	27	100%	3,879	0	100%	17,924	98

McNielORAWMvHR2.4

NUTRIENT MANAGEMENT

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET
Version H&Rv2.4

11/21/2005
STATE: OREGON

CLIENT: **Wil-View Farms Dairy**
ASSISTED BY: **Bruce Wilson**

CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

NUTRIENT BALANCE BASED ON AVAILABLE ACRES

Field Number	Acres	Crop	NUTRIENTS APPLIED - Nitrogen, N Lbs/Acre	NUTRIENTS APPLIED - Phosphorous, P_2O_5 Lbs/Acre	NUTRIENTS APPLIED - Potassium, K_2O Lbs/Acre	NUTRIENTS REMOVED - Nitrogen, N Lbs/Acre	NUTRIENTS REMOVED - Phosphorous, P_2O_5 Lbs/Acre	NUTRIENTS REMOVED - Potassium, K_2O Lbs/Acre	NUTRIENT BALANCE = Nitrogen, N Lbs/Acre	NUTRIENT BALANCE = Phosphorous, P_2O_5 Lbs/Acre	NUTRIENT BALANCE = Potassium, K_2O Lbs/Acre
6	42.0	Corn, Silage(AH)	101	127	275	154	80	184	-53	47	91
6	42.0	Ryegrass Haylage	85	42	86	200	73	205	-115	-32	-119
3,4,5,7,8	80.2	Hay/Pasture Mix 14% Protein	179	87	180	179	49	137	0	38	43
0											
0											
0											
0											
0											
0											
Off-Farm											

NUTRIENT MANAGEMENT

Field Nutrient Balance

Tract No Field No Acres	Crop Name	Crop Yield	Crop Year	Crop Removal (lb/ac)			Credits (lb/ac)			Manure (lb/ac)			Fertilizer (lb/ac)			Nutrient Balance (lb/ac)		
				N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O
McNiel T673 3 16.7	Hay/Pasture Mix (16% Protein)	4 Tons	2006	205	57	157	166	81	167	0	0	0	0	0	0	-39	24	10
			Totals	**205**	**57**	**157**	**166**	**81**	**167**	**0**	**0**	**0**	**0**	**0**	**0**	**-39**	**24**	**10**
McNiel T673 4 9.7	Hay/Pasture Mix (16% Protein)	4 Tons	2006	205	57	157	166	81	167	0	0	0	0	0	0	-39	24	10
			Totals	**205**	**57**	**157**	**166**	**81**	**167**	**0**	**0**	**0**	**0**	**0**	**0**	**-39**	**24**	**10**
McNiel T673 5 18.7	Hay/Pasture Mix (16% Protein)	4 Tons	2006	205	57	157	166	81	167	0	0	0	0	0	0	-39	24	10
			Totals	**205**	**57**	**157**	**166**	**81**	**167**	**0**	**0**	**0**	**0**	**0**	**0**	**-39**	**24**	**10**
McNiel T673 6 42	Corn, silage	30 Tons	2006	231	120	275	0	0	0	218	176	528	0	0	0	-13	56	253
	Hay/Pasture Mix (16% Protein)	4 Tons	2006	205	57	157	85	42	86	60	48	144	0	0	0	-60	33	73
			Totals	**436**	**177**	**432**	**85**	**42**	**86**	**278**	**224**	**672**	**0**	**0**	**0**	**-73**	**89**	**326**
McNiel T673 7 12.1	Hay/Pasture Mix (16% Protein)	4 Tons	2006	205	57	157	166	81	167	0	0	0	0	0	0	-39	24	10
			Totals	**205**	**57**	**157**	**166**	**81**	**167**	**0**	**0**	**0**	**0**	**0**	**0**	**-39**	**24**	**10**
McNiel T673 8 21.9	Hay/Pasture Mix (16% Protein)	4 Tons	2006	205	57	157	166	81	167	0	0	0	0	0	0	-39	24	10
			Totals	**205**	**57**	**157**	**166**	**81**	**167**	**0**	**0**	**0**	**0**	**0**	**0**	**-39**	**24**	**10**
McNiel T696 1 7.4	Hay/Pasture Mix (16% Protein)	4 Tons	2006	205	57	157	166	81	167	34	27	82	0	0	0	-5	51	92
			Totals	**205**	**57**	**157**	**166**	**81**	**167**	**34**	**27**	**82**	**0**	**0**	**0**	**-5**	**51**	**92**

Credits are nutrients generated from pasturing animals or other preapplication credits.

USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

Ecological Sciences Divison

October 2003

Nutrient Management Technical Note No. 1

Effects of Diet and Feeding Management on Nutrient Content of Manure

Introduction

Accumulation of excess nutrients on the farm results in a whole-farm nutrient imbalance that can contribute to water and air pollution. A major portion of nutrients brought onto livestock and poultry farms comes from purchased feeds. Reducing nutrients or selecting more efficient feed nutrient sources and/or feeding techniques can significantly reduce the nutrient content of excreted manure (helping to achieve a whole farm nutrient balance), and help to reduce odors and other gaseous emissions from manure.

The U.S. Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) released *Unified National Strategy for Animal Feeding Operations* in March 1999. Importantly, the Strategy articulated a national performance expectation that all animal feeding operations should develop and implement technically sound, economically feasible, and site-specific comprehensive nutrient management plans (CNMPs) to minimize potential adverse impacts on water quality and public health. Feed management is one component of a CNMP.

Proper management of animal diets is a valuable tool to help balance nutrient flows, to achieve a whole-farm nutrient balance, and to reduce the potential negative impacts some nutrients have on the environment.

This technical note describes a series of basic nutrition and feeding management principles and potential adjustments that can be made on livestock and poultry operations to reduce nutrient excretions. This technical note was prepared from material published by the Federation of Animal Science Societies (FASS), Savoy, Illinois (fass@assochg.org). Additional technical notes provide specific feeding management and nutrient excretion information for beef, dairy, poultry, and swine. These technical notes are not intended to be all-inclusive. Farmers or operators should consult with Extension personnel or qualified animal nutritionists for detailed information and thorough evaluations of the animal diets and feeding management programs for livestock or poultry operations.

This is the first in a series of nutrient management technical notes on feeding management.

Series was prepared by **Dr. Alan Sutton,** professor of Animal Science at Purdue University, West Lafayette, Indiana, and **Charles H. Lander,** national agronomist, NRCS, Washington, DC. This series was developed from material published by the Federation of Animal Science Societies (FASS), Savoy, Illinois.

Digestive processes

The digestive process begins with the intake of feed ingredients provided to meet animal maintenance, production, and reproduction requirements. The requirements for production are affected by stage of growth and the type of product (e.g., meat, milk, eggs) involved. How well the animal can retain nutrients for productive purposes depends upon the bioavailability of the nutrients in the diet, absorption, and metabolism. The quantity of nutrients excreted by animals is affected by three main factors:

- the amount of dietary nutrients consumed,
- the efficiency with which they are utilized by the animal for growth and other functions, and
- the amount of normal metabolic losses (endogenous). In other words, the amount of excreted nutrients can be expressed as:

Nutrients excreted = Nutrient intake – Nutrients utilized + Nutrients from endogenous sources

The primary way to reduce the amount of nutrients excreted by animals is to decrease the amount that is consumed and increase the efficiency of utilization of the dietary nutrients for formation of the product.

The goal of efficient and productive feeding of animals, within economic and environmental constraints, is to provide essential available nutrients for maintenance and production with minimal excess amounts.

Nutrients in feeds can vary considerably, and not all nutrients in feeds are available to the animal. Therefore, any means of increasing the digestibility or availability of nutrients will increase the potential for animal use and retention and reduce the amount of nutrients excreted. There is increasing interest today in using enzymes, genetically modified feed ingredients, and feed-processing technologies to enhance the availability of nutrients so as to meet the specific animal needs and reduce excretion of nutrients. In addition, a routine feed analysis program is imperative so that diets can be formulated and periodically adjusted to meet, but not exceed, the nutrient requirements of the animal.

Ruminants and nonruminants have different digestive systems. The ruminant (cattle and sheep) is capable of digesting and utilizing nutrients and energy from forages as well as from the easily digestible grains (concentrates). The nonruminant (poultry and swine) cannot effectively use a large amount of forages (fiber). Also, poultry and swine cannot digest some of the nutrients, particularly phytate phosphorus (P) contained in grains. Usually, 50 percent of the P in the grains and oilseeds is in the form of phytate, which is not available to swine and poultry. Therefore, to meet their P requirements, their diets must include additional P, generally supplied by mineral supplements. The combination of the P in feed grains and the additional mineral P added to the diet increases the total P consumed by the animal. A considerable portion of the nonavailable P and/or extra P not needed by the animal is excreted. If the diet contains an enzyme called phytase, which will release the phytate form of phosphorus from the grains, then supplemental phosphorus in the diets can be reduced.

Following are some factors that should be considered for making adjustments in the diet or feeding program to reduce anticipated excretion of nutrients and manure volume. In all cases, nutrients should be managed to meet the animal needs and, of equal importance, to minimize nutrient excesses.

Feed management factors

Recommended feed management practices for a particular operation may include implementation of grouping strategies, including grouping by gender and increasing the number of production groups; appropriately adjusting diets based on climatic factors; minimizing feed wastage; and employing processing options to improve feed use efficiency. Further information is provided in the species-specific technical notes.

Grouping—(1) Place animals of similar ages, weights, and/or production levels together. (2) Place animals of the same gender together. Split-sex feeding divides the animals by gender so that diets can be formulated to meet the special nutrient needs of each sex.

Climate—Adjust diet to meet specific climate conditions (e.g, temperature, wind, precipitation), or adjust the building climate to optimize nutrient utilization.

Phase feeding—Use multi-phase feeding versus minimal-phase feeding. Phase feeding provides a series of diets that are formulated to more closely meet the nutrient needs of the animal at a particular stage of growth or production. Dividing the growth period into several periods with a smaller spread in body weight allows producers to provide diets that more closely meet the animal's nutrient requirements.

Wastage—Minimize feed and water spillage.

Processing—Pelleting, extrusion, steaming, micronization, ensiling, and reducing particle size increase the digestibility of diets for swine and poultry. Processing feeds (e.g., grinding, pelleting, and fermenting) releases nutrients in the diet so the animal can absorb and retain more nutrients and excrete less nutrients and manure volume. Processing is not as critical for ruminants; however, coarse grinding, ensiling, and steaming have been effective for ruminants.

Diet manipulation factors

Diet considerations that are described in more detail in the technical notes on individual species include formulation based on feed available nutrients, the use of growth promotants to improve feed use efficiency, consideration of genetic factors that influence nutrient needs, use of specialty feeds, and consideration of nutrient intake from water supplies.

Available nutrients—Know the availability of nutrients in feed ingredients and formulate diets based upon available nutrients in the feed ingredients. Nutritionists should use the respective National Research Council (NRC) nutrient requirements for each farm animal as a guide to formulating diets unless data are available on the farm showing nutrient requirements of a specific genetic line of animals.

Nutrient levels—Some nutrient levels in commercial animal diets may be excessive. Chemical analyses of ingredients and reformulation are critical to minimizing excesses.

Genetics—Know the genetic capability of the animal, including feed intakes and responses to environmental conditions (e.g., climate, disease pressure, housing system).

Growth promoters—Antibiotics and other growth promoters increase feed efficiency. Growth promoters reduce nutrient excretion by increasing nutrient utilization.

Specialty feeds—Providing specific feed ingredients (e.g., high-oil corn, nutrient-dense corn, low-phytate corn, and soybeans) helps achieve a proper balance or increased availability of nutrients. Some of these are not commercially available today, but may be so in the near future.

Water supplies—Water supply sources can contribute significantly to mineral intakes.

Supplemental phosphorus—Reduce supplemental P and add phytase to swine and poultry diets to reduce P excretion. Remove all supplemental P in beef cattle diets and most of the supplemental P in dairy cattle diets to reduce P excretion.

Crude protein—Reduce dietary protein content and add synthetic amino acids to swine and poultry diets; reduce protein and select nitrogen (N) sources that cattle can absorb more effectively.

Benefits of reducing nutrients

Reducing the nutrient content of farm animal manure has the following benefits:

- A smaller land base per animal unit is required for manure application. This may provide a means to balance nutrients on a whole-farm basis.
- Greater volumes of manure can be applied per acre of land to meet agronomic rates for crop production. This may result in less labor and fuel costs for land application and reduce the potential need to supplement crop nutrient budgets with commercial fertilizer. Applying greater amounts of organic matter from manure per acre could result in more carbon sequestration and reduced emissions of gases responsible for global warming.
- Reduced N and sulfur excretion have the potential to reduce odors.

Reduced volumes of manure production will reduce the requirement for manure storage capacity and increase the flexibility for timing of manure application to cropland.

Dietary adjustments

The table on page 4 provides potential reductions in the excretion of nutrients with the dietary and/or feeding management adjustments mentioned above for livestock and poultry on operations that have not yet adopted diet and/or feeding management strategies to reduce manure nutrient content. It should be noted, however, that these potential effects are not additive. For more specific information, see the FASS fact sheets and the NRCS technical notes in this series for the specific animal species.

Potential reductions in the excretion of nutrients

Strategy	Nitrogen reduction (%)	Phosphorus reduction (%)
Formulate diet closer to requirement	10–15 (nonruminants) 10–25 (ruminants)	10–15 (nonruminants) 10–30 (ruminants)
Reduced protein/AA supplementation (nonruminants)	10–25 (poultry) 20–40 (swine)	n/a [1]
Protein manipulation (ruminants)	15–25	n/a [1]
Use of highly digestible feeds	5	5
Use of phytase/low P (nonruminants)	2–5	20–30
Selected enzymes	5	5
Growth promotants	5	5
Phase feeding	5–10	5–10
Split-sex feeding	5–8	n/a [1]

1 Not applicable.

Table data adapted from Federation of Animal Science Societies (FASS) publication, *Dietary Adjustments to Minimize Nutrient Excretion from Livestock and Poultry*, January 2001.

• • • • • •

Glossary terms used in the series of nutrient management technical notes

Available nutrient basis. Formulating a diet based on the bioavailability of the nutrients from the feed ingredients in the diet for the intended production purposes.

Bacterial protein (BCP). The crude protein in rumen bacteria made up of amino acids and nucleic acids.

Barrow. Male castrate of swine.

Bioavailability of nutrients. The amount of nutrient in the diet that is released in the digestion process and that can be absorbed in a form that can be used in the body for normal metabolic functions of the nutrient.

Bovine growth hormone. A natural nonsteroidal protein hormone produced in the pituitary glands of cattle that helps cows produce milk. The growth hormone produced in cattle will only be effective in cattle. This protein has been produced synthetically in bacteria.

Broiler. Chicken produced for meat.

By-products. Feed ingredients from sources that are normally waste products from other industries.

Concentrates. Plant materials (feeds) that contain relatively high starch content.

Crude protein. A measure of dietary protein that is based on the assumption that the average amino acid in a protein contains 16 percent nitrogen. Thus, total chemically determined nitrogen × 6.25 (100 ÷ 16) = crude protein.

Crystalline amino acid. Amino acid produced in its pure chemical form.

Cystine. A sulfur-containing amino acid that can replace up to one-half of the methionine requirement.

Degradable intake protein (DIP). Crude protein that is degraded in the rumen by micro-organisms.

Denitrification. The process by which nitrogen is converted to nitrogen gas (N_2) and nitrous oxide (N_2O) and returned to the atmosphere.

Diet formulation. The process of combining an assortment of feed ingredients into a diet that will meet the nutrient and energy requirements of the animal for the intended purpose for which the animal is produced.

Digestibility. The relative amount of nutrients released from the digestion process.

Digestion. The process of breaking down nutrients through chewing and the action of enzymes to release nutrients that can be absorbed in animals.

Dry-matter intake. The amount of completely dry feed consumed by animals.

Dry precipitation. Chemicals combining in the atmosphere and falling to Earth.

Endogenous. Nutrients within the animal that may be produced or synthesized. Excretion of endogenous nutrients may occur from the recycling of nutrients and normal cellular metabolic processes.

Endogenous phytase. The enzyme naturally derived within the animal or from microbial sources within the animal that degrades phytate and releases phosphorus.

Feed use efficiency. The amount of live weight gain, milk production, or egg production per unit of feed consumed.

Fermentation by-products. By-products that have been processed by anaerobic fermentation.

Fermented feeds. Feeds that have been processed and preserved by anaerobic fermentation. A typical example is the acid fermentation of whole corn plant silage.

Forage. Plant material that contains relatively high fiber content.

Gilt. A term used to describe young female swine before sexual maturity.

Grass tetany. A nutritional disease caused by inadequate magnesium in the blood. It most commonly occurs among lactating animals grazing on rapidly growing, lush spring pastures containing less than 0.2 percent magnesium and more than 3 percent potassium and 4 percent nitrogen.

Ideal protein basis. Formulating a diet based on the concept that the protein content of the diet has a balance of amino acids that exactly meets the animal's amino acid requirements.

Layer. A chicken raised to produce eggs.

Leaching. The process by which plant nutrients move down through the soil profile, potentially reaching ground water.

Lysine. A basic amino acid required for growth.

Metabolizable protein (MP). Protein (amino acids) absorbed from the small intestine of ruminants. Contains bacterial protein and undegraded intake protein.

Methionine. A sulfur-containing amino acid required for growth.

Microbial protein synthesis. The process by which protein is synthesized in the rumen as micro-organisms grow and multiply.

Near infrared spectroscopy. Feed analysis performed using near infrared light wave reflectance.

Nonruminant (monogastric). An animal that has a simple stomach (one compartment) and must utilize concentrate diets.

Phase feeding—Changing the nutrient concentrations in a series of diets formulated to meet an animal's nutrient requirements more precisely at a particular stage of growth or production.

Phytase. An enzyme that degrades phytate, making phosphorus available to nonruminants.

Phytate phosphorus. A complex, organic form of phosphorus that is bound to the phytate molecule and is not readily digested by nonruminant animals.

Precision nutrition. Providing the animal with the correct ratio and quantity of nutrients in a diet at the ideal ratio to most efficiently produce the end product for which the animal is raised.

Ruminant. An animal capable of digesting forages (roughages) because it has a large stomach with four compartments that have micro-organisms present.

Somatotropin. The hormone that regulates growth, affects the metabolism of all classes of nutrients, stimulates milk production, and improves productive efficiency.

Sparing effect. The process whereby one chemical or metabolite reduces the need or requirements for another nutrient.

Split sex feeding. A feeding and housing program that divides animals by gender and formulates diets to meet the specific nutrient requirements of each sex more precisely.

Total digestible nutrients (TDN). Total of all the nutrients in the diet that are available to the animal.

Undegraded intake protein (UIP). Feed protein that is not degraded in the rumen by micro-organisms.

Volatilization. The process by which chemicals evaporate at ordinary temperatures.

Wet-chemistry procedures. Analysis of nutrients using standard, approved laboratory procedures.

Wet-dry feeding systems. Feeding systems designed to introduce water with dry feeds, either at prescribed times or at any time on demand by the animal. By introducing water at the time of feeding, the potential for water spillage and dust from feed sources is reduced.

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USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

Ecological Sciences Divison

October 2003

Nutrient Management Technical Note No. 5

Feed and Animal Management for Dairy Cattle

Introduction

Dairy operations typically include the milking cow herd with some of the cow population in the nonlactation stage (dry cows). Operations may or may not include growing heifers being raised as replacements for the milking herd. Distinctly different diets are required for each of the three production cycle stages, resulting in great differences in the volume and nutrient compositions of manure. This technical note briefly highlights some factors that affect nutrients in manure from dairy cattle and modifications in the diet that can be used to reduce them.

A critical part of feed management is to accurately formulate diets and manage the feeding so that the nutrients fed consistently match the nutrients needed by each group in the herd. For example, table 1 shows how the concentration of nutrients needed in the diet change with stage of the life cycle and level of milk production. This table is an example to illustrate how the diet formula needs to be specific for each group in the herd. The concentration of nutrients needed in the diet for a particular level of production changes with dry matter intake.

Diet formulation

Diets should be formulated and updated regularly to avoid overfeeding of nutrients or fluctuations in milk production. The most common guideline for diet formulation is the National Research Council's (NRC) publication, Nutrient Requirements of Dairy Cattle, 2001. This publication provides equations to compute nutrient requirements for any size cow and milk production level and any stage of the life cycle. Therefore, actual dry matter intakes and a computer program that includes NRC and/or other research-based equations should be used to formulate diets. Because of the complexity of formulating diets to optimize production while minimizing excretion, producers not trained in nutrition should obtain help from qualified nutritionists when formulating diets. Proper diet formulation requires routine (monthly or quarterly) forage and by-product analysis because these ingredients are highly variable. Tabular values and previous sample analyses are not reliable for determining the nutrient content of these feed ingredients. Conducting a routine moisture analysis is important to adjust and mix feeds to ensure delivery of the formulated diet to the cattle. Cows should be evaluated for their body condition routinely so that the proper energy level of the diet can be determined.

This is the fifth in a series of nutrient management technical notes on feeding management.

Series was prepared by **Dr. Alan Sutton,** professor of Animal Science at Purdue University, West Lafayette, Indiana, and **Charles H. Lander,** national agronomist, NRCS, Washington, DC. This series was developed from material published by the Federation of Animal Science Societies (FASS), Savoy, Illinois.

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A 50 percent variation in manure production might result from differences in feed wastage, ration formulation, type of feeding program (e.g., dry lot versus pasture feeding), and/or animal grouping systems.

Since dairy cattle are ruminants, they can utilize forages (generally lower in digestibility) as well as concentrates (generally higher in digestibility) in their diets. Depending upon the stage of production, the roughage-to-concentrate ratio can vary tremendously. As a result, volumes of manure produced are much greater when poorly digestible forages (fiber) are fed as compared to concentrates. In addition, the availability of nutrients in forages can vary considerably with different forage species and stage of maturity. Also, the composition of the manure is significantly different with these different scenarios.

Studies have shown that selecting the right type of protein sources in the diet to meet animal requirements can reduce nitrogen (N) excretion by 15 to 25 percent. Most of the N consumed by cattle is a part of the protein the animal consumes. When cows consume excess protein, an increased amount of N is excreted in the urine as urea. Small amounts of urea can also be diffused into the milk. The concentration of urea in milk is proportional to the amount of N excreted in urine for cows with a given body weight. Cows consuming excess protein typically have higher milk urea nitrogen (MUN) concentration than cows consuming protein at or below their requirements. MUN can be measured for use as an indicator of excess protein in the diet. A general rule is that an average herd MUN should fall between 9 and 14 mg/decaliter of milk. The current recommendation from the NRC (2001) for phosphorus (P) feeding is a range of about 0.32 to 0.42 percent of dietary dry matter content, depending upon level of milk production and stage of lactation. Yet many producers are feeding closer to 0.5 percent for all lactating cows. Farmers often overfeed P with the thought that (1) they will improve reproductive efficiency, and (2) the feed ingredient tables typically underestimate the amount of P in most ingredients.

Mineral P supplements, such as dicalcium phosphate or monocalcium phosphate, are added to dairy cow diets at levels exceeding recommendations to provide a safety margin, especially if reproductive problems

Table 1 Selected nutrient requirements of dairy cattle (as determined by sample diets) [1]

Holstein, 1,500 lb cow, avg. body condition, 65 months of age	Stage of production						Dry, preg. 270 days in gestation	660 lb heifer @ 1.91 lb gain/day
	early lactation		90 days in milk					
Milk yield, lb/d =	55	77	55	77	99	120	BW=1,656 lb	
Dry matter intake, lb/d	29.7	34.3	44.7	51.9	59.2	66	30.1	15.6
Net energy, Mcal/lb	0.94	1.01	0.62	0.67	0.70	0.73	0.48	1.03
Diet, % RDP	10.5	10.5	9.5	9.7	9.8	9.8	8.7	9.4
Diet, % RUP	7	9	4.6	5.5	6.2	6.9	2.1	2.9
Crude protein, % [2]	17.5	19.5	14.1	15.2	16.0	16.7	10.8	12.3
NDF, min %	25–33	25–33	25–33	25–33	25–33	25–33	33	30–33
NFC, max %	36–44	36–44	36–44	36–44	36–44	36–44	42	34–38
Calcium, %	0.74	0.79	0.62	0.61	0.67	0.60	0.45	0.41
Phosphorus, %	0.38	0.42	0.32	0.35	0.36	0.38	0.23	0.23
Potassium, % [3]	1.19	1.24	1.00	1.04	1.06	1.07	0.52	0.48
Sodium, %	0.34	0.34	0.22	0.23	0.22	0.22	0.10	0.08
Copper, mg/kg [4]	16	16	11	11	11	11	13	10
Zinc, mg/kg	65	73	43	48	55	65	22	27

1 Adapted from tables 14–7, 14–8, 14–9, and 14–16, Nutrition Requirements of Dairy Cattle, 7th revised edition, 2001, National Research Council (NRC), National Academy of Sciences, National Academy Press, 2101 Constitution Ave., Washington, DC 20418 (J.H. Clark, chair, Subcommittee on Dairy Nutrition).
2 Equivalent to the sum of rumen degradable protein (RDP) and rumen undegradable protein (RUP) only when they are perfectly balanced.
3 Heat stress may increase the need for potassium.
4 High dietary molybdenum, sulfur, and iron can interfere with copper absorption, increasing the requirement.

are suspected. As a result, diets typically contain 25 to 35 percent more P than is recommended by the NRC. By reducing or removing all supplemental P in the dairy diet, P excretion in manure can be reduced by as much as 30 percent.

Overfeeding P for reproductive performance has no scientific basis. Research shows that using accurate requirements for P along with actual feed analysis to formulate diets optimizes animal performance and minimizes P concentration in manure. Forages in particular are highly variable in P content and should be determined for each farm, using wet-chemistry procedures.

By-products (e.g., products of the brewing and distilling industries) are often utilized in cattle diets. Balancing the proper nutrient levels in cattle diets can be challenging when by-products are used. A consideration in the use of by-products is that the concentration and availability of nutrients, especially N and P, from each feed ingredient source can vary greatly, causing significant variation in nutrient contents that can create excesses in the diet.

The dietary salt intake level should be reduced in cattle feeds in semiarid and arid climates where salinity problems can exist and sodium accumulation can adversely affect crop production. In addition, beware of potassium accumulation in forages receiving high levels of manure application. This can potentially cause grass tetany problems in cattle consuming such forages.

Production management

Several new technologies have the potential to reduce manure nutrients per 100 pounds of milk produced. Average responses from some research studies are used in this technical note. Actual responses vary from farm to farm and from group to group within a farm.

One such technology is the manipulation of photoperiod by providing artificial lighting. It has been shown that increasing day length can increase milk production in dairy cattle by up to 8 percent. Nutrient intake required by such light-stimulated herds increased by only 4.1 percent, and N and P excretion increased by only 2.8 percent as compared with similar herds under natural day length.

Penning and grouping dairy cattle of similar milk production levels or stage of lactation and formulating diets to meet more nearly the nutritional needs of cattle reduce feed nutrient wastage. Uniform groups (by weight and stage of production) allow the producer to use diets that more closely match the actual needs of all animals in the group since there is less variation among animals, and overfeeding of nutrients can be minimized.

Dividing the milk production cycle into several periods with less variation in milk production within the group allows producers to provide diets that more closely meet the cattle's nutrient requirements. Use of phase feeding has been estimated to reduce N and P excretion by at least 5 to 10 percent.

Another new technology that may impact nutrient utilization and excretion is the administration of bovine growth hormone (BGH), or somatotropin. This peptide hormone can increase milk production by as much as 30 percent in certain cows within the herd, although the entire herd's production would increase by only 14 percent. The nutrient requirements of a herd treated with BGH may increase by about 7 to 8 percent, and manure P may increase by 5 percent. However, the nutrient losses from the farm per unit of milk produced would, therefore, decrease by 8 to 10 percent per unit of milk produced.

Milking three times instead of twice per day can increase production per cow by an average of 11 percent and reduce stress on a herd. This increase in production results in the consumption of 5 percent more protein, with 3.5 percent more nutrients excreted in manure. The extra milking per day reduces the amount of nutrient excreted in manure by 7 percent per unit of milk.

Feed management

Feed bunk management. Good bunk management is imperative to reduce feed wastage. This involves checking feed intake levels for each group in the herd and adjusting intake to that required for the production level of each group. Consideration should also be given to how much feed is being wasted. In some operations leftovers are scraped up from lactating cows and re-fed to nonlactating cattle. In other cases refused feed is scraped from the feeding area and discarded. In this situation waste removed from the lot includes wasted feed and manure nutrients that need to be applied to the land.

Feed storage. Proper feed storage is necessary to preserve the nutrient value of the feed and to reduce direct loss of nutrients to the environment. Nutrients

in water can come from leachate from fermented feeds (such as silage) and from runoff from feeds exposed to rain. Containment of silage leachate and good management of all feed storage areas are advised so that feed-based nutrients are not lost directly to the environment.

Nutritional value of water. The mineral content of the water supply should be considered with regard to the total intake of dietary minerals. Depending on the quality of water supply available, water intake may make a substantial contribution to daily mineral intake, particularly with regard to sulfur and, in some areas of the country, salt. Routine water sampling can help the nutritionist formulate properly for the amount of minerals to add to the diet to meet the animal's actual requirements.

Summary

The NRC publication *Nutrient Requirements for Dairy Cattle*, 2001, is a key reference to evaluate dairy cattle diets on a commercial operation. Also consult qualified nutritionists to accurately evaluate current or planned diet compositions during the development of a conservation plan, particularly during the development of a Comprehensive Nutrient Management Plan (CNMP). Various feed management activities can impact the nutrient content of excreted dairy cattle manure. Table 2 lists the potential of various feed management strategies to decrease the N and/or P content of manure excreted by dairy animals.

The actual impact of a feed management strategy or strategies on a dairy operation can only be determined by analysis of the manure after the strategy has been implemented. During the development of CNMPs, the potential impact of such strategies can be estimated using values in table 2. In using data from this table, planners are encouraged to be conservative in their selection of factors. Also, it is important to remember that the impact of using multiple strategies in a single diet is not likely to be additive for each single strategy used. Rather, it is more likely to be something greater than the value for the strategy with the smallest impact, but less than the sum of the values for all the individual strategies used.

During the development of CNMPs, it is better to underestimate the potential impact of feed management than to overestimate it. Later, the plan can be modified based on data accumulated from the actual production operation.

Glossary

By-products. Feed ingredients from sources that are normally waste products of other industries.

Bovine growth hormone. A natural nonsteroidal protein hormone produced in the pituitary glands of cattle that helps cows produce milk. The growth hormone produced in cattle will only be effective in cattle. This protein has been produced synthetically in bacteria.

Concentrate. Plant materials (feeds) that contain relatively high starch content.

Diet formulation. The process of combining an assortment of feed ingredients into a diet that will meet the nutrient and energy requirements of the animal for the intended purpose for which the animal is produced.

Forage. Plant material that contains a relatively high fiber content.

Phase feeding. Changing the nutrient concentrations in a series of diets formulated to meet an animal's nutrient requirements more precisely at a particular stage of growth or production.

Somatotropin. The hormone that regulates growth, affects metabolism of all classes of nutrients, stimulates milk production, and improves efficiency.

Table 2 Potential for feed management to impact the nutrient content of dairy cattle manure [1]

Strategy	Nitrogen reduction %	Phosphorus reduction %
Minimize dietary nutrient excesses	10–15	10–30
Protein manipulation	15–25	n/a [2]
Increase number of production groups	5–10	5–10

1 Adapted from the Federation of Animal Science Societies (FASS) publication, *Dietary Adjustments to Minimize Nutrient Excretion from Livestock and Poultry*, January 2001.
2 Not applicable.

OPERATIONS

Proper management is an essential component of every Comprehensive Nutrient Management Plan (CNMP). The following guidelines accompanied with necessary corrective action will help ensure the CNMP is implemented successfully.

SAFETY

Waste collection and management facilities should be kept in a state of good repair and safe operating condition at all times. Warning signs, ladders, ropes, bars, rails, and other safety devices should be provided, as appropriate, to help insure the safety of humans and livestock. Each device should be structurally adequate to support anticipated loads. (A rope may be adequate sight warning, but inappropriate to support a person who accidentally slips on wet concrete.)

At least four noxious gasses are generated when organic waste is subject to anaerobic processes. They are: Methane (CH_4), Hydrogen Sulfide (H_2S), Ammonia (NH_3) and Carbon Dioxide ($C0_2$). In high enough concentrations, all can be lethal through lack of oxygen or poisoning. (Three gases are heavier than air and will exclude oxygen from depressed areas.) All but carbon dioxide can be explosive. Ventilation and warning signs must be provided for enclosed waste holding structures to help prevent explosions, poisoning or asphyxiation. Pipelines from an enclosed tank(s) in a building should be provided with a water - sealed trap and vent to prevent gas entry into the building. Entry into pits, ponds or tanks should not be allowed but if entry cannot be avoided the following procedures should be adhered to:

1) **Ventilate the facility before and during occupancy and use a self-contained breathing apparatus. Do not assume any storage tank, including open top storage tanks, are well ventilated.**
2) **Attach a tether or lead capable of supporting the wait of the person entering the facility and have a person outside the facility at all times tend the tether or lead.**

When inspecting or working on machinery, the following procedures should be adhered to:

1) **Disconnect all power connections and provide lockouts whenever possible.**
2) **Use blocks in front and behind rolling equipment to prevent movement.**

OPERATIONS

ANIMAL MORTALITY MANAGEMENT

Having dead animals sent to an acceptable disposal site is the best method to deal with animal mortalities. A list of disposal sites can be found on the internet at http://www.deq.state.or.us/wmc/solwaste/disposal.html. Under no circumstances are animal mortalities to be disposed of in any liquid storage facility.

Currently animal mortalities for this operation are being disposed of by Denley Rendering Service. As an alternative one of the following methods may be used:

Natural Disposal- To allow nature to take its course the dead animal needs to be transported to a location at least ½ mile from any off-farm dwelling and at least ¼ mile from any water way in accordance with ORS 601.140. Once this criteria is met the carcass can be left to degrade naturally with the help of scavengers.

Landfill- Dead animals may be transported to a permitted landfill that accepts animal carcasses for disposal. Be sure to call the chosen landfill first to insure a landfill will accept your animal carcasses. Refer to the website given previously for permitted landfills to call. Contact the landfill operator and the DEQ at (800) 452-4011 if the landfill you would like to use is not a permitted facility to see if an exception may be granted for the disposal of animal carcasses.

Incineration- Dead animals may be burned as a method of disposal and as a method to control diseases. Contact your DEQ at (800) 452-4011 for guidance on incineration of animal carcasses.

Burial- Dead animals may be buried as a method of disposal. Large animals such as an adult cow will require a hole approximately 2 feet by 7 feet by 8 feet deep. Be sure to select a site that doesn't have a water table to insure the bottom of the hole will be dry. The animal carcass should be covered with hydrated lime and covered with at least 4 feet of soil mounded 2 feet above the natural ground line to allow for settling as the carcass decomposes. Burial sites should be located at least 500 feet down slope from surface waters or wells.

OPERATIONS

IRRIGATION WATER MANAGEMENT (PS449)

Irrigation Water Management (IWM) is applying water according to crop needs in an amount that can be stored in the plant root zone of the soil. Following are the basic formulas that may be helpful to apply the principles of irrigation water management:

Equation 1:

$$Q * T = d * A$$

where:

Q = flow rate (cfs or acre-in/hr)
T = time (hr)
d = gross depth applied (in)
A = area (acres)

Equation 2:

$$Q = \frac{453 * A * d}{f * H}$$

where:

Q = flow rate (gpm)
A = area (acres)
d = gross application depth (in)
f = irrigation frequency (days)
H = hours of operation per day

Water Flow Rates:

1 cubic foot per second (cfs)
= 448.8 gallons per minute
1 cfs for 1 hour = 0.99 acre-inch
1 cfs for 24 hr = 1.98 acre-ft
1,000 gpm = 2.23 cfs
1,000 gpm for 24 hr = 4.42 ac-ft
1 cfs = 40 miner's inches in OR, AZ, MT, No. CA
1 cfs = 50 miner's inches in ID, KS, NE, NM, ND, SD, So. CA
1 cfs = 38.4 miner's inches in CO
1 cfs = 28.32 liters/sec
1 cfs = 0.02832 cubic meters/s
1 cubic meter/sec = 35.3 cfs
1 liter/sec = 15.85 gpm

Pump Power Requirement:

$$\text{Horsepower} = \frac{\text{Pump Head in ft} * \text{gpm}}{3960 * \text{Pump Efficiency}}$$

Water Volumes & Weights:

1 cubic foot = 7.48 gallons
= 62.4 lb
= 28.3 liters
1 acre-foot = 43,560 cubic feet
(1 acre covered 1 ft deep)
12 acre-inches = 1 acre-ft
1 million gallons = 3.07 acre-ft
1 acre-ft = 1,234 cubic meters
1 cubic meter = 1,000 liters

Pressure and Pressure Head:

1 psi = 2.31 ft of pressure head
1 atmosphere (sea level)
= 14.7 psi = 33.9 ft of head

Lengths and Areas:

1 mile = 5,280 ft = 1.61 km
1 meter = 3.28 ft = 39.37 inches
1 acre = 43,560 square ft
1 hectare = 2.47 acres

OPERATIONS

Irrigation Water Management Worksheet for Wil-View Farms

Crop Name:	**Pasture/Hayland**					
Managed Rooting Depth:	**30 inches**					
Management Allowed Depletion, MAD:	**50 %**					
Irrigated Acres:	**86.5**					
Soil Name:	**Helvetia, Jory, Quatama, Saum, Woodburn**					
Soil Depth (inches):	**60**					
Available Water Capacity (in/in):	**.17**					
Soil Intake Rate (in/hr) :	**.5**					
IRRIGATION REQUIREMENT HOW MUCH water to apply?	**Month**					
	April	**May**	**June**	**July**	**August**	**Sept**
Total Plant Available Water Capacity (in): Soil or Root Depth * Available Water Capacity	5.10	5.10	5.10	5.10	5.10	5.10
Net Irrigation Application (in): Total Plant Available Water Capacity * MAD	2.55	2.55	2.55	2.55	2.55	2.55
Irrigation System Application Rate (in/hr): Determined based on the type of Irrigation System	0.38	0.38	0.38	0.38	0.38	0.38
IRRIGATION TIMING WHEN to apply water?						
Net Irrigation Water Requirement (in):	1.57	3.15	4.57	6.22	5.12	3.46
Average Daily Crop Water Use (in/day):	0.05	0.10	0.15	0.20	0.17	0.12
Irrigation Frequency (days): Net Irrigation Application / Daily Crop Water Use	30	26	17	13	15	21
Irrigation System Set Time (hours):	7.5	7.5	7.5	7.5	7.5	7.5
Actual Net Irrigation Application (in): Gross Application * System Application Efficiency	2.00	2.00	2.00	2.00	2.00	2.00
Actual Irrigation Frequency (days): Actual Net Irrigation Application / Daily Crop Water Use	**30**	**20**	**13**	**10**	**12**	**17**
IRRIGATION SYSTEM CAPACITY						
System Application Efficiency (%): Water Required / Water Applied	70	70	70	70	70	70
Gross Irrigation Application (in): System Application Rate * System Set Time	2.85	2.85	2.85	2.85	2.85	2.85
Volume of Water per Irrigation (acre-in): Gross Irrigation Application * Irrigated Acres	247	247	247	247	247	247
Irrigation System Operation (hours/day):	16	16	16	16	16	16
Required System Flow Rate (gpm): (Equation 2)	**233**	**349**	**537**	**698**	**582**	**411**
Compare **Required** system flow rate with **Measured** flow noted on **Irrigation Application Record**						

OPERATIONS

Irrigation Water Management Worksheet for Wil-View Farms

Crop Name:	**Corn Silage**
Managed Rooting Depth:	**48 inches**
Management Allowed Depletion, MAD:	**50 %**
Irrigated Acres:	**42**
Soil Name:	**Quatama, Woodburn**
Soil Depth (inches):	**60**
Available Water Capacity (in/in):	**.17**
Soil Intake Rate (in/hr) :	**.5**

IRRIGATION REQUIREMENT HOW MUCH water to apply?	Month					
	April	**May**	**June**	**July**	**August**	**Sept**
Total Plant Available Water Capacity (in): Soil or Root Depth * Available Water Capacity	8.16	8.16	8.16	8.16	8.16	8.16
Net Irrigation Application (in): Total Plant Available Water Capacity * MAD	4.08	4.08	4.08	4.08	4.08	4.08
Irrigation System Application Rate (in/hr): Determined based on the type of Irrigation System	0.38	0.38	0.38	0.38	0.38	0.38
IRRIGATION TIMING WHEN to apply water?						
Net Irrigation Water Requirement (in):	0	0.47	3.62	7.13	5.83	1.06
Average Daily Crop Water Use (in/day):	0.00	0.02	0.12	0.23	0.19	0.04
Irrigation Frequency (days): Net Irrigation Application / Daily Crop Water Use	0	31	30	18	21	30
Irrigation System Set Time (hours):	7.5	7.5	7.5	7.5	7.5	7.5
Actual Net Irrigation Application (in): Gross Application * System Application Efficiency	2.00	2.00	2.00	2.00	2.00	2.00
Actual Irrigation Frequency (days): Actual Net Irrigation Application / Daily Crop Water Use	**0**	**31**	**17**	**9**	**11**	**30**
IRRIGATION SYSTEM CAPACITY						
System Application Efficiency (%): Water Required / Water Applied	70	70	70	70	70	70
Gross Irrigation Application (in): System Application Rate * System Set Time	2.85	2.85	2.85	2.85	2.85	2.85
Volume of Water per Irrigation (acre-in): Gross Irrigation Application * Irrigated Acres	120	120	120	120	120	120
Irrigation System Operation (hours/day):	16	16	16	16	16	16
Required System Flow Rate (gpm): (Equation 2)	**0**	**109**	**199**	**377**	**308**	**113**

Compare **Required** system flow rate with **Measured** flow noted on **Irrigation Application Record**

OPERATIONS

To meet the peak consumptive use in July for 86.5 acres of pasture/hay land, a minimum flowrate of 698 gallons per minute will be needed and for 42 acres of corn for silage, a minimum flowrate of 377 gallons per minute will be needed. Use a set time of 5 hours or a travel speed of 0.9 feet per minute when using a "Big Gun" sprinkler to irrigate with assuming a sprinkler flowrate of 350 gallons per minute and a wetted diameter of 300 feet. The spacing for the "Big Gun" sprinkler should be approximately 240 feet to insure proper water distribution in the irrigated area. Following these guidelines when irrigating will ensure at least 2 inches of water is applied per irrigation. If runoff is noted during irrigations, offset the "Big Gun" sprinkler spacing to prevent runoff losses.

The "feel and appearance method" shown on the next page is one of several irrigation scheduling methods used in IWM. It is a way of monitoring soil moisture to determine when to irrigate and how much water to apply. Applying too much water causes excessive runoff and/or deep percolation. As a result, valuable water is lost along with nutrients and chemicals, which may leach into the ground water.

The feel and appearance of soil vary with texture and moisture content. Soil moisture conditions can be estimated, with experience, to an accuracy of about 5 percent. Soil moisture is typically sampled in one-foot increments to the root depth of the crop at three or more sites per field. It is best to vary the number of sample sites and depths according to crop, field size, soil texture, and soil stratification. For each sample the "feel and appearance method" involves:

1. Obtaining a soil sample at the selected depth using a probe, auger, or shovel;
2. Squeezing the soil sample firmly in your hand several times to form an irregularly shaped "ball";
3. Squeezing the soil sample out of your hand between thumb and forefinger to form a ribbon;
4. Observing soil texture, ability to ribbon, firmness and surface roughness of ball, water glistening, loose soil particles, soil/water staining on fingers, and soil color. [Note: A very weak ball will disintegrate with one bounce of the hand. A weak ball disintegrates with two to three bounces];
5. Comparing observations with photographs and/or charts to estimate percent water available and the inches depleted below field capacity.

FEEL AND APPEARANCE METHOD OF DETERMINING SOIL MOISTURE

Clay, Clay Loam, and Silty Clay Loam Soils

Appearance of Clay, Clay Loam, and Silty Clay Loam Soils at Various Soil Moisture Conditions

AVAILABLE WATER CAPACITY = 1.6 TO 2.4 INCHES PER FOOT

Percent Available: Currently available soil moisture as a percent of available water capacity.
Inches per Foot Depleted: Inches of water needed to refill a foot of soil to field capacity.

0 TO 25 PERCENT AVAILABLE 2.4 TO 1.2 INCHES PER FOOT DEPLETED

Dry, soil aggregations separate easily, clods are hard to crumble with applied pressure. (Not pictured)

25 TO 50 PERCENT AVAILABLE 1.8 TO 0.8 INCHES PER FOOT DEPLETED

Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure.

50 TO 75 PERCENT AVAILABLE 1.2 TO 0.4 INCHES PER FOOT DEPLETED

Moist, forms a smooth ball with defined finger marks, light soil/water staining on fingers, ribbons between thumb and forefinger.

75 TO 100 PERCENT AVAILABLE 0.6 TO 0.0 INCHES PER FOOT DEPLETED

Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily between thumb and forefinger.

OPERATIONS

NUTRIENT MANAGEMENT (PS590)

In order to effectively apply nutrient management, soils, crops, irrigation water, manure, waste water, dry stack solids need to be tested in accordance with the following schedule-

- Sample liquid manure and solids from the waste storage facilities during applications. Have each sample analyzed for Total Nitrogen, Phosphorus & Potassium plus Salts and Solids
- Collect at least one soil sample from the application areas in accordance with **Oregon State University Extension publication EM8832-E** in Section 13 every fall (September-October). Have soil samples analyzed for Nitrates (NO_3-N), Phosphorus and Potassium.

If current tests show a variation of more than 15% when compared to previous tests, the nutrient management recommendations need to be reviewed, new nutrient budgets and phosphorus indexes prepared as necessary by using computer software or copies of the nutrient budget and phosphorus worksheets on the next page. Be sure to use realistic yield goals and account for all nutrient sources when developing a new nutrient budget. Also consider effects of drought or excess moisture when determining nutrient availability.

Follow the guidance given in **Oregon State University Extension publication EM 8650, "The Pre Side Dress Soil Nitrate Test"** and **EM 8832-E, "Post Harvest Soil Nitrate Test"** in Section 13 to monitor and adjust manure application based on nitrogen. If fall soil samples indicate excessive nitrate nitrogen (NO_3-N>30PPM), nitrogen applications must be reduced by reducing manure applications and excess manure must be transferred off farm for utilization.

If soil test values for phosphorus increase prepare a new phosphorus risk index following guidance given in Section 6. If the phosphorus index shows high site vulnerability for the current application areas then nutrients budgets must be based on phosphorus uptake and manure applications to utilization areas reduced.

Refer to the Waste Application and Utilization part of this section for guidance in applying manure, waste water, and other organic material to meet nutrient budget requirements for the planned crops. Always perform the following tasks annually before making manure applications:

- Review nutrient management component of this plan annually and make adjustments when needed.
- Calibrate application equipment to ensure uniform distribution and accurate application rates.
- Avoid unnecessary exposure to organic waste and wear protective clothing when necessary.
- Observe set backs required for manure applications adjacent to water bodies, drainageways, and other sensitive areas.
- Maintain records of nutrient application as required by state and local regulations.
- Clean up residual materials from equipment and dispose of properly.

Refer to Oregon State University Extension Service publications **PNW570-E, "Monitoring Soil Nutrients Using a Management Unit Approach" and EC1478, "Soil Test Interpretation Guide"** included in Section 13 for guidance in monitoring soil nutrients and interpreting soil test results.

OPERATIONS

Nutrient Budget Worksheet for Wil-View Farms

Tract Number _____ Field number _____

PURPOSE (Check all that apply)			
Budget and supply nutrients for plant production		Utilize manure/organic materials as a nutrient source	
Minimize agricultural non-point source pollution (water quality)		Maintain or improve soil Condition	

Table 1. Field Conditions and Recommendations	
CROP SEQUENCE/ROTATION (circle current crop)	EXPECTED YIELD

CURRENT SOIL TEST LEVELS (ppm or lb/ac)					
N	P	K	pH	S.O.M %	EC

RECOMMENDED NUTRIENTS/AMENDMENTS TO MEET EXPECTED YIELD					
N	P_2O_5	K_2O	LIME	Other_____	Other_____

Table 2. Nutrient Sources						
Credits	N		P_2O_5		K_2O	
	Pounds per acre					
1. Nitrogen credits from previous legume crop						
2. Residual from long-term manure application						
3. Irrigation water						
4. Other (e.g., atmospheric deposition)						
5. **Total credits**						
Plant-Available Nutrients Applied to Field	N		P_2O_5		K_2O	
(Circle column that is landuser's decision)	Trial A	Trial B	Trial A	Trial B	Trial A	Trial B
6. Credits (from row 5, above)						
7. Fertilizer – Starter						
7. Fertilizer – Other						
8. Manure / Organic Materials						
9. **Subtotal (sum of lines 6, 7 and 8)**						
10. **Nutrients Recommended (from Table 1)**						
11. **Nutrient Status (subtract line 10 from line 9)**						
If line 11 is a negative number, this is the amount of additional nutrients needed to meet the crop recommendation.						
If line 11 is a positive number, this is the amount by which the available nutrients exceed the crop requirements.						

1. NUTRIENT MANAGEMENT SPECIFICATIONS

Amount to be Applied(lb./ac)	**N**		**P_2O**		**K_20**	
Method, Form, and Timing of Application:						

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Wil-View Farms	Tract No.	Field No(s):	Date:	
Soil Map Unit(s):	Soil Test P – Planned: ppm Current: ppm	Lab. Method: Weak Bray P1	Sample Depth: 12 inches	
Planner:	Notes:			

		PHOSPHORUS LOSS RATING					Weighted Rating Value	
TRANSPORT FACTORS	Factor Weight	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	**Planned**	**Current**
Soil Erosion – tons/ac/yr (RUSLE)	1.50	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)		
Soil Erosion from Sprinkler Irrigation	0.75	No sprinkler irrigation (0)	Application rate < infiltration rate OR No visible runoff at field borders (0.75)	Application rate = infiltration rate OR Little to no visible runoff at field borders (1.5)	Application rate > infiltration rate OR Visible runoff at field borders (3.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (6.0)		
Runoff Class	1.00	Negligible (0)	Very low or low (1.0)	Medium (2.0)	High (4.0)	Very High (8.0)		
Flooding Frequency Class	0.75	None or very rare (0)	Rare (0.75)	Occasional (1.5)	Frequent (3.0)	Very Frequent (6.0)		
Distance to Perennial Surface Waters / Buffer Widths	0.75	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.75)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.5)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (3.0)	< 100 feet AND No buffer next to surface waters (6.0)		
Subsurface Drainage	0.50	No Tile Drains (0)	Tile drains present Soil Test P (Bray P1) < 60 ppm (0.5)	Tile drains present Soil Test P (Bray P1) 61 - 140 ppm (1.0)	Tile drains present Soil Test P (Bray P1) 141- 190 ppm (2.0)	Tile drains present Soil Test P (Bray P1) > 190 ppm (4.0)		
						Transport Factors Subtotal (TFS)		

OPERATIONS

Tract :	Fields:	PHOSPHORUS LOSS RATING					Weighted Rating Value	
SOURCE FACTORS	Factor Weight	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	**Planned**	**Current**
Soil Test P – ppm (Bray P1)	1.00	(Soil Test P – 40) x 0.10 (_____ - 40) x 0.10 = _____ Assign 0 points if Soil Test P < 40 ppm						
Commercial P Fertilizer Application Rate	1.00	lbs/ac P_2O_5 x 0.02 _____ lbs/ac P_2O_5 x 0.02 = _____						
Commercial P Fertilizer Application Method	1.00	None Applied (0)	Injected / banded deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)		
Organic P Source Application Rate	1.00	lbs/ac P_2O_5 x 0.02 _____ lbs/ac P_2O_5 x 0.02 = _____						
Organic P Source Application Method	1.00	None Applied (0)	Injected deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)		

Total Rating Value TFS + SFS	***SITE VULNERABILITY CLASS***			
< 13.0	**Low**	**Transport Factors Subtotal (TFS)**		
13.0 – 25.0	**Medium**	**Source Factors Subtotal (SFS)**		
25.1 – 50.0	**High**	**Total Rating Value (TFS + SFS)**		
> 50.0	**Very High**	**Site Vulnerability Class**		

OPERATIONS

PASTURE AND HAYLAND MANAGEMENT (PS528A, PS511)

The perennial grass-legume pasture shall be grazed on a rotational basis. A minimum of 3 units are required and each unit shall be rested for a period of not less than 20 days or until plants are 6 to 8 inches in height. Grazing shall begin when plants are 6 to 8 inches in height and discontinued when the plants are grazed to a height of 3-4 inches. Overgrazing can cause the quantity and quality of forage to be reduced. Provide dry roughage to reduce the bloat hazard when cattle are grazing on pasture with more than 40 percent legumes. Avoid grazing when soil is saturated.

Apply fertilizer and animal waste in accordance with the guidance given in the NUTRIENT MANAGEMENT and WASTE UTILIZATION parts of this section.

The pasture shall be clipped and dragged a minimum of twice annually to promote uniform grazing and avoid damage to the plants and/or a reduction in forage production. Clipping and dragging after each grazing period will promote optimum pasture conditions.

If rodent, insect or weed control becomes a problem, a pest management program may need to be included. See your local OSU Extension Agent for recommended pest control methods.

Based on a target yield of 4 tons per acre and 10 acre grazing units, the maximum stocking rate is 20 animal units for each grazing unit. If it is not practical or desirable to harvest all of the grazeable forage with livestock, consideration should be given to harvest the excess forage as hay. The perennial grass-legume pastures should be cut for hay between the heading and flowering stage. The minimum plant height after cutting should be 3 inches.

When making hay, cut grasses when they are in the boot stage to produce hay with high quality protein and insure the minimum plant height after cutting is 3 inches to maximize production. Before harvest, clear fields of debris that could damage machinery, or if ingested by livestock, lead to sickness or death.

Delay harvest if prolonged or heavy precipitation is forecast that would seriously damage cut forage or forage swaths or windrows would smother underlying plants before removal from the field. Where weather conditions make it difficult to harvest the desired quality of forage, use mechanical or chemical conditioners and/or ensile. When harvested for ensilage forage should be chopped to a size that allows adequate packing to produce the anaerobic conditions necessary to ensure the proper ensiling process.

Harvest silage/haylage crops at the ideal moisture range for the type of storage planned. Treat direct cut hay crop silage with chemical preservatives or add dry feed stuffs to avoid fermentation and seepage digestible dry matter losses. For optimal forage quality, rake, ted, or invert swaths, and bale when hay has sufficient moisture to prevent leaf loss. Bale at optimum moisture levels to preserve forage quality and quantity. Approximate percent moisture should be as follows:

- Bale field cured hay at 15 to 20 percent moisture.
- Bale forced air dried hay at 20 to 35 percent moisture.
- Rake hay at 30 to 40 percent moisture.
- Ted or invert swaths when moisture is above 40 percent.

Inspect and repair harvesting equipment following the manufacturer's preventative maintenance procedures. All shields shall be in place during machine operation to prevent injury or death. Shut off machinery before working on or unplugging moving parts.

OPERATIONS

WASTE APPLICATION AND UTILIZATION (PS633)

Do not spread manure on field areas where soils are saturated, ponded and/or flooded during times when manure runoff into open watercourses is likely. Do not apply waste to fields with frozen or snow covered soil conditions unless provisions are made to control runoff.

The following guidelines should be adhered to if emergency applications of manure and waste water must be made due to some unforeseen situation such as the storage facilities being full and overtopping is imminent:

a) Spread manure only on fields identified on the plan map as emergency application areas.
b) Spread manure no closer than 100 feet from an open watercourse.
c) Make no manure applications during a rainfall event or when the soils are saturated.
d) Minimize application rates by using the maximum travel rates for the application equipment.
e) Maintain records of emergency applications and do not apply commercial fertilizer to fields receiving emergency applications unless soil tests indicate to do so.

No fields are subsurface (TILE) drained which require additional precautions when manure is applied. Manure applied to subsurface drained fields can follow soil macropores directly to the tile drains creating a surface water pollution hazard from direct tile discharge. Tillage prior to manure application that can disrupt/close (using horizontal fracturing) the preferential flow paths (worm holes, cracks, root channels) in the soil will reduce the risk of a manure discharge to surface waters. Any pre-application tillage should leave as much residue as possible on the soil surface. Water control structures installed in subsurface drainage systems should be managed to prevent discharge of manure and waste water during periods of application.

Always perform the following tasks annually to make manure and waste water applications:

- Review current soil tests and insure they do not vary more than 15% with soil tests used to develop crop nutrient budgets in the Nutrient Management section. If current soil tests vary more than 15% when compared with previous soil tests, then refer to the Nutrient Management part of this section for guidance on developing new nutrient budgets.
- Inspect and repair manure hauling and application equipment to minimize potential of accidental spillage.
- Avoid unnecessary exposure to manure and waste water and wear protective clothing when necessary.
- Be aware of the location of sensitive areas, concerns of neighbors or concerns of the public, which require special application procedures. To reduce odor problems, apply manure and waste water in mid morning when temperatures are warming and air is rising rather than in the afternoon or evening when air is cooling and settling. Avoid applications during periods of fog.
- Calibrate application equipment to ensure uniform distribution and accurate application rates in accordance with guidance given in the nutrient budget for the field applying to. Refer to the following pages for calibration worksheets and make copies as necessary to document the calibration of application equipment.
- Apply manure in accordance with the recommendations given on the nitrogen and phosphorus application worksheets located on the following pages. The example application rate calculations on the worksheets are based on the original nutrient budgets and estimated equipment calibrations done to prepare this plan. Use copies of the worksheets to document calculations made to determine new application rates based on revised nutrient budgets or calibrations of application equipment.
- Apply manure and waste water in a manner that will cover no more than 25 percent of the leaf surface with solids unless clean water applications are planned immediately after wastes are applied. For pasture/hay land it is best to apply waste 7 days after harvesting forage by haying or grazing.
- When applying manure and waste water, maintain a **35 foot** setback from down-gradient surface waters, open tile line intake structures, sinkholes, well heads or other sensitive areas to prevent a prohibited discharge of manure and waste water.

- Record manure and waste water applications on the appropriate form in section 10 and maintain them for at least 5 years.
- Clean up residual materials from equipment and dispose of properly.

Refer to Oregon State University Extension Service publications **PNW505, "Which Test is Best? Customizing Dairy Manure Testing"** and **EM 8586, "Dairy Manure as a Fertilizer Source"** included in Section 13 for guidance in collecting manure samples for testing and utilizing dairy manure as a fertilizer source.

OPERATIONS

Spreader Equipment Calibration for Wil-View Farms

(Using Bucket, Pan or Tarp)

Name:_____ Date:_____

Perform the following operations to calibrate the solids spreader equipment:

- ✓ Place buckets, pans, or tarps in the application area to collect the applied or spread waste material.
- ✓ Spread waste material over the application area using the spreading pattern normally used in the field. Make sure the spreader is traveling at the speed it typically travels over the collection area. Record engine rpm and gear settings used.
- ✓ Collect and weigh the waste material and calculate the average application rate. Use this worksheet to record the weights and calculations.

Note: Use Tarps instead of buckets or pans when using dry stack manure or separated solids as the variability in the weight will be less.

Data and Calculations:

Steps	ID of Bucket, Pan or Tarp				
	A	B	C	D	E
1. Date of calibration test-					
2. Engine RPM during spreading -					
3. Gear selected during spreading -					
4. Weight of empty bucket (lb) =					
5. Weight of bucket with waste (lb) =					
6. Weight of Waste (lb) - line 5 – line 4 =					
7. Collection Area (sq ft) - Area of the top of the bucket, pan or tarp used to collect the waste =					
8. Waste Applied (lb/sq ft) - line 6 ÷ line 7 =					
9. Covert to tons per acre - line 8 x 21.78 =					
10. Average Application Rate (tons per acre)- Sum of values in cells A9 through F9 divided by the total number of calibrations completed =					

Additional Notes:

OPERATIONS

Spreader Equipment Calibration for Wil-View Farms

(Using a Full Spreader Load)

Name:_____ Date:_____

Perform the following operations to calibrate the solids spreader equipment:

- ✓ Determine the weight of the waste material loaded in the spreader by using truck scales to weigh the spreader equipment when it is empty and full.
- ✓ Spread the loaded spreader on the field using consistent speed and spreader settings to cover the field uniformly. Spread in a rectangular pattern so the area calculation will be simple. Record engine rpm and gear settings used.
- ✓ Measure the length and width covered by the full load and compute the application rate in tons per acre using this worksheet.

Data and Calculations:

Steps	ID of Calibration Test				
	A	B	C	D	E
1. Date of calibration test-					
2. Engine RPM during spreading -					
3. Gear selected during spreading -					
4. Weight of empty spreader (lb) =					
5. Weight of loaded spreader (lb) =					
6. Weight of Waste in spreader (lb) - line 5 – line 4 =					
7. Length of spreading area (ft) =					
8. Width of spreading area (ft) =					
9. Area spread (sq ft) - line 7 x line 8 =					
10. Waste applied (lb/sq ft) – line 6 ÷ line 9=					
11. Convert to tons per acre - Line 10 x 21.78=					
12. Average Application Rate (tons per acre) – Sum of values in cells A11 through F11 divided by the total number of calibrations completed =					

Additional Notes:

OPERATIONS

Tank Equipment Calibration for Wil-View Farms

(Using a Full Tank Load)

Name:_____ Date:_____

Perform the following operations to calibrate the tank equipment:

- ✓ Determine the maximum capacity of the tank equipment from the manufacturer's maintenance manual or the owners manual for the equipment.
- ✓ Fill the tank and reduce the volume of the tank by the appropriate amount if the tank is not filled to its maximum capacity. Normally a tank spreader is only filled to about 80 percent of its maximum capacity and therefore the maximum rated capacity of the tank should be multiplied by 0.8 to reflect the volume of the loaded tank during the calibration exercise.
- ✓ Spread the loaded tank on the field using consistent speed and settings to cover the field uniformly. Try to spread in a rectangular pattern so the area calculation will be simple. Record engine rpm and gear settings used.

Data and Calculations:

Steps	ID of Calibration Test				
	A	B	C	D	E
1. Date of calibration test-					
2. Engine RPM during spreading-					
3. Gear selected during spreading-					
4. Maximum rated capacity of tank (gallons) =					
5. Volume of filled tank (gallons)- Line 4 x ____ % of tank filled ÷ 100% =					
6. Length of spreading area (ft) =					
7. Width of spreading area (ft) =					
8. Area spread (sq ft)- line 6 x line 7 =					
9. Waste applied (gal/sq ft)- line 5 ÷ line 8 =					
10. Convert to gallons per acre - Line 9 x 43,560 =					
11. Average Application Rate (gallons per acre) – Sum of values in cells A10 through F10 divided by the total number of calibrations completed =					

Additional Notes:

OPERATIONS

Traveling Big Gun Sprinkler Calibration for Wil-View Farms

Name:_____ Date:_____

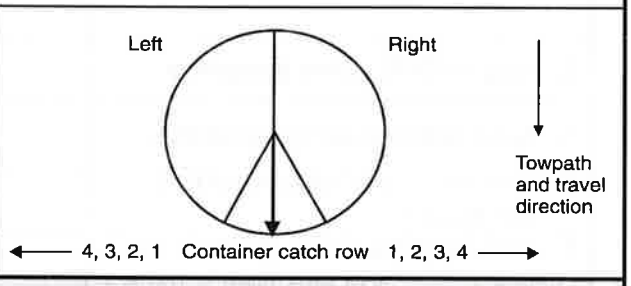
Perform the following operations to calibrate the traveling big gun sprinkler:

- ✓ Use 5 to 10 catch cans to collect the sprinkler-irrigated waste. Use straight-sided buckets for catch cans. Two pound coffee cans work well. Make sure all of the catch cans have the same diameter.
- ✓ Place one of the catch cans on a level surface and fill it with water to a known depth (1-3 inches). Pour the water from the catch can into a large measuring cup. Determine how many measuring cups of water are equal to an inch of water in the catch can.
- ✓ Place at least five catch cans across the towpath of the big gun sprinkler. Try to space the catch cans uniformly from the center of the towpath to the outer edge of the wetted area of the sprinkler. Stake the catch can in place or put a rock in the bottom of the catch can to keep it upright. Allow the traveling big gun sprinkler to completely pass over the catch cans. Use the measuring cup previously used to calibrate the catch cans to measure the amount of liquid collected in each can and convert the volume to inches. Be sure to add together the amount measured from the catch cans that would receive overlap from the adjacent towpath. For example, if catch can #4 will receive liquids from the adjacent towpaths, add the amount from container #4 on the left to container #4 on the right side to compute the total amount applied at the location of container #4 on the right and left sides of the towpath.

Catch Can Calibration:

Example: 1 inch = 5 Cups
1 cup = 0.2 Inches

Your Catch Cans: 1 inch = _____ Cups
1 cup = _____ Inches



Travel Rate Setting During Test:

Data and Calculations:

Catch Can ID	Volume of Liquid							
	Cups	Inches	Cups	Inches	Cups	Inches	Cups	Inches
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
Average =								

OPERATIONS

Nitrogen Based Waste Application for Wil-View Farms

Name:_____ Date:_____

Planned Application:

Corn silage is being grown and the total recommended nutrient application from the nutrient management section is 218 pounds of nitrogen (N) per acre. A traveling big gun sprinkler will be used to make 2-109 pound applications of nitrogen from a waste storage pond that will not be incorporated into the field.

Waste application rates and amounts:

Steps	Planned Application		Current Application	
	Liquid	Solids	Liquid	Solids
1. Crop receiving waste-	**Corn Silage**			
2. Desired nitrogen application rate, lb/acre-	109	NA		
3. Nutrient concentrations in storage from laboratory analysis or from Table 1-1: **Nitrogen (N)-**	lb/1000 gal 8	lb/ton NA	lb/1000 gal	lb/ton
Phosphorus (P_2O_5)-	4	NA		
Potassium (K_2O)-	12	NA		
4. Plant availability of nitrogen from Table 1-1 in percent-	100 %	100 %	%	%
5. Nitrogen retained, in percent, after application from Table 1-2-	75 %	70 %	%	%
6. Calculate nitrogen availability- N line 3 x line 4 x line 5 ÷ 10,000=	lb/1000 gal 6.00	lb/ton 0.00	lb/1000 gal	lb/ton
7. Determine nitrogen application rate from the nutrient application charts: **Nitrogen (N)-**	inches/acre 0.67	tons/acre 0	inches/acre	tons/acre
8. Determine the amount of phosphorus and potassium applied from nutrient concentration data on line 3 and nutrient application charts: **Phosphorus (P_2O_5)-**	lb/acre 73	lb/acre 0	lb/acre	lb/acre
Potassium (K_2O)-	218	0		
9. Total Nutrients Applied, lb/acre: **Nitrogen (N)-** (Sum of liquids and solids from line 2)	**109 lb/acre**			**lb/acre**
Phosphorus (P_2O_5)- (Sum of liquids and solids from line 8)	**73 lb/acre**			**lb/acre**
Potassium (K_2O)- (Sum of liquids and solids from line 8)	**218 lb/acre**			**lb/acre**

OPERATIONS

Nitrogen Based Waste Application for Wil-View Farms

Name:_____ Date:_____

Planned Application:

A ryegrass relay crop is being grown as a winter cover crop on the field where corn silage is grown and the total recommended nutrient application from the nutrient management section is 115 pounds of nitrogen (N) per acre. A traveling big gun sprinkler will be used to make a 60 pound application of nitrogen from a waste storage pond that will not be incorporated into the field. A tractor spreader will be used to make a 55 pound application of nitrogen from the dry pack source of manure and bedding that will not be incorporated.

Waste application rates and amounts:

Steps	Planned Application		Current Application	
	Liquid	Solids	Liquid	Solids
10. Crop receiving waste-	**Corn Silage**			
11. Desired nitrogen application rate, lb/acre-	60	55		
12. Nutrient concentrations in storage from laboratory analysis or from Table 1-1: **Nitrogen (N)-**	lb/1000 gal 8	lb/ton 9	lb/1000 gal	lb/ton
Phosphorus (P_2O_5)-	4	4		
Potassium (K_2O)-	12	19		
13. Plant availability of nitrogen from Table 1-1 in percent-	100 %	100 %	%	%
14. Nitrogen retained, in percent, after application from Table 1-2-	75 %	70 %	%	%
15. Calculate nitrogen availability- N line 3 x line 4 x line 5 ÷ 10,000=	lb/1000 gal 6.00	lb/ton 6.30	lb/1000 gal	lb/ton
16. Determine nitrogen application rate from the nutrient application charts: **Nitrogen (N)-**	inches/acre 0.37	tons/acre 9	inches/acre	tons/acre
17. Determine the amount of phosphorus and potassium applied from nutrient concentration data on line 3 and nutrient application charts: **Phosphorus (P_2O_5)-**	lb/acre 40	lb/acre 36	lb/acre	lb/acre
Potassium (K_2O)-	121	171		
18. Total Nutrients Applied, lb/acre: **Nitrogen (N)-** (Sum of liquids and solids from line 2)	**115 lb/acre**			**lb/acre**
Phosphorus (P_2O_5)- (Sum of liquids and solids from line 8)	**76 lb/acre**			**lb/acre**
Potassium (K_2O)- (Sum of liquids and solids from line 8)	**292 lb/acre**			**lb/acre**

OPERATIONS

Nitrogen Based Waste Application for Wil-View Farms

Name:_____ Date:_____

Planned Application:

Pasture/Hay Land is being grown and the recommended nutrient application from the nutrient management section is 34 pounds of nitrogen (N) per acre. A traveling big gun sprinkler will be used to make a 34 pound application of nitrogen from a waste storage pond that will not be incorporated into the field.

Waste application rates and amounts:

Steps	Planned Application		Current Application	
	Liquid	Solids	Liquid	Solids
1. Crop receiving waste-	**Pasture/Hayland**			
2. Desired nitrogen application rate, lb/acre-	34	NA		
3. Nutrient concentrations in storage from laboratory analysis or from Table 1-1: **Nitrogen (N)-**	lb/1000 gal 8	lb/ton NA	lb/1000 gal	lb/ton
Phosphorus (P_2O_5)-	4	NA		
Potassium (K_2O)-	12	NA		
4. Plant availability of nitrogen from Table 1-1 in percent-	100 %	100 %	%	%
5. Nitrogen retained, in percent, after application from Table 1-2-	75 %	70 %	%	%
6. Calculate nitrogen availability- N line 3 x line 4 x line 5 ÷ 10,000=	lb/1000 gal 6.00	lb/ton 0.00	lb/1000 gal	lb/ton
7. Determine nitrogen application rate from the nutrient application charts: **Nitrogen (N)-**	inches/acre 0.21	tons/acre 0	inches/acre	tons/acre
8. Determine the amount of phosphorus and potassium applied from nutrient concentration data on line 3 and nutrient application charts: **Phosphorus (P_2O_5)-**	lb/acre 23	lb/acre 0	lb/acre	lb/acre
Potassium (K_2O)-	68	0		
9. Total Nutrients Applied, lb/acre: **Nitrogen (N)-** (Sum of liquids and solids from line 2)	**34 lb/acre**		**lb/acre**	
Phosphorus (P_2O_5)- (Sum of liquids and solids from line 8)	**23 lb/acre**		**lb/acre**	
Potassium (K_2O)- (Sum of liquids and solids from line 8)	**68 lb/acre**		**lb/acre**	

OPERATIONS

Nitrogen Based Waste Application for Wil-View Farms

Name:_____ Date:_____

Planned Application:

Pasture/Hay Land is being grown and the recommended nutrient application from the nutrient management section is 34 pounds of nitrogen (N) per acre. A tractor spreader will be used to make a 34 pound application of nitrogen from the dry pack source of manure and bedding that will not be incorporated into the field.

Waste application rates and amounts:

Steps	Planned Application		Current Application	
	Liquid	Solids	Liquid	Solids
10. Crop receiving waste-	**Pasture/Hayland**			
11. Desired nitrogen application rate, lb/acre-	NA	34		
12. Nutrient concentrations in storage from laboratory analysis or from Table 1-1: **Nitrogen (N)-**	lb/1000 gal NA	lb/ton 9	lb/1000 gal	lb/ton
Phosphorus (P_2O_5)-	NA	4		
Potassium (K_2O)-	NA	19		
13. Plant availability of nitrogen from Table 1-1 in percent-	100 %	100 %	%	%
14. Nitrogen retained, in percent, after application from Table 1-2-	75 %	70 %	%	%
15. Calculate nitrogen availability- N line 3 x line 4 x line 5 ÷ 10,000=	lb/1000 gal 0.00	lb/ton 6.30	lb/1000 gal	lb/ton
16. Determine nitrogen application rate from the nutrient application charts: **Nitrogen (N)-**	inches/acre 0.00	tons/acre 5	inches/acre	tons/acre
17. Determine the amount of phosphorus and potassium applied from nutrient concentration data on line 3 and nutrient application charts: **Phosphorus (P_2O_5)-**	lb/acre 0	lb/acre 20	lb/acre	lb/acre
Potassium (K_2O)-	0	95		
18. Total Nutrients Applied, lb/acre: **Nitrogen (N)-** (Sum of liquids and solids from line 2)	**34 lb/acre**			**lb/acre**
Phosphorus (P_2O_5)- (Sum of liquids and solids from line 8)	**20 lb/acre**			**lb/acre**
Potassium (K_2O)- (Sum of liquids and solids from line 8)	**95 lb/acre**			**lb/acre**

OPERATIONS

Phosphorus Based Waste Application for Wil-View Farms

Name:_____ Date:_____

Planned Application:

Corn silage is being grown and the total recommended nutrient application from the nutrient management section is 120 pounds of phosphorus (P_2O_5) per acre. A traveling big gun sprinkler will be used to make 120 pound applications of phosphorus from a waste storage pond that will not be incorporated into the field.

Waste application rates and amounts:

Steps	Planned Application		Current Application	
	Liquid	Solids	Liquid	Solids
1. Crop receiving waste-	**Corn Silage**			
2. Desired phosphorus application rate, lb/acre-	120	NA		
3. Nutrient concentrations in storage from laboratory analysis or from Table 1-1: **Nitrogen (N)-**	lb/1000 gal 8	lb/ton NA	lb/1000 gal	lb/ton
Phosphorus (P_2O_5)-	4	NA		
Potassium (K_2O)-	12	NA		
4. Determine phosphorus application rate from the nutrient application charts: **Phosphorus (P_2O_5)-**	inches/acre 1.10	tons/acre 0	inches/acre	tons/acre
5. Plant availability of nitrogen from Table 1-1 in percent-	100 %	100 %	%	%
6. Nitrogen retained, in percent, after application from Table 1-2-	75 %	70 %	%	%
7. Calculate nitrogen availability- N line 3 x line 4 x line 5 ÷ 10,000=	lb/1000 gal 6.00	lb/ton 0.00	lb/1000 gal	lb/ton
8. Determine the amount of nitrogen and potassium applied from nutrient concentration data on line 3 and nutrient application charts: **Nitrogen (N)-**	lb/acre 179	lb/acre 0	lb/acre	lb/acre
Potassium (K_2O)-	358	0		
9. Total Nutrients Applied, lb/acre: **Nitrogen (N)-** (Sum of liquids and solids from line 8)	**179 lb/acre**			**lb/acre**
Phosphorus (P_2O_5)- (Sum of liquids and solids from line 2)	**120 lb/acre**			**lb/acre**
Potassium (K_2O)- (Sum of liquids and solids from line 8)	**358 lb/acre**			**lb/acre**

OPERATIONS

Phosphorus Based Waste Application for Wil-View Farms

Name:_____ Date:_____

Planned Application:				
Corn silage is being grown and the total recommended nutrient application from the nutrient management section is 120 pounds of phosphorus (P_2O_5) per acre. A tractor spreader will be used to make 120 pound applications of phosphorus from the dry pack manure and bedding source that will not be incorporated into the field.				
Waste application rates and amounts:				
Steps	**Planned Application**		**Current Application**	
	Liquid	**Solids**	**Liquid**	**Solids**
10. Crop receiving waste-	**Corn Silage**			
11. Desired phosphorus application rate, lb/acre-	NA	120		
12. Nutrient concentrations in storage from laboratory analysis or from Table 1-1: **Nitrogen (N)-**	**lb/1000 gal** NA	**lb/ton** 9	**lb/1000 gal**	**lb/ton**
Phosphorus (P_2O_5)-	NA	4		
Potassium (K_2O)-	NA	19		
13. Determine phosphorus application rate from the nutrient application charts: **Phosphorus (P_2O_5)-**	**inches/acre** 0.00	**tons/acre** 30	**inches/acre**	**tons/acre**
14. Plant availability of nitrogen from Table 1-1 in percent-	100 %	100 %	%	%
15. Nitrogen retained, in percent, after application from Table 1-2-	75 %	70 %	%	%
16. Calculate nitrogen availability- N line 3 x line 4 x line 5 ÷ 10,000=	**lb/1000 gal** 0.00	**lb/ton** 6.30	**lb/1000 gal**	**lb/ton**
17. Determine the amount of nitrogen and potassium applied from nutrient concentration data on line 3 and nutrient application charts: **Nitrogen (N)-**	**lb/acre** 0	**lb/acre** 189	**lb/acre**	**lb/acre**
Potassium (K_2O)-	0	570		
18. Total Nutrients Applied, lb/acre: **Nitrogen (N)-** (Sum of liquids and solids from line 8)	**189 lb/acre**			**lb/acre**
Phosphorus (P_2O_5)- (Sum of liquids and solids from line 2)	**120 lb/acre**			**lb/acre**
Potassium (K_2O)- (Sum of liquids and solids from line 8)	**570 lb/acre**			**lb/acre**

OPERATIONS

Phosphorus Based Waste Application for Wil-View Farms

Name:_____ Date:_____

Planned Application:

Pasture/Hay Land is being grown and the recommended nutrient application from the nutrient management section is 57 pounds of phosphorus (P_2O_5) per acre. A traveling big gun sprinkler will be used to make a 57 pound application of phosphorus from waste storage pond that will not be incorporated.

Waste application rates and amounts:

Steps	Planned Application		Current Application	
	Liquid	Solids	Liquid	Solids
19. Crop receiving waste-	**Pasture/Hayland**			
20. Desired phosphorus application rate, lb/acre-	57	NA		
21. Nutrient concentrations in storage from laboratory analysis or from Table 1-1: **Nitrogen (N)-**	lb/1000 gal 8	lb/ton NA	lb/1000 gal	lb/ton
Phosphorus (P_2O_5)-	4	NA		
Potassium (K_2O)-	12	NA		
22. Determine phosphorus application rate from the nutrient application charts: **Phosphorus (P_2O_5)-**	inches/acre 0.52	tons/acre 0	inches/acre	tons/acre
23. Plant availability of nitrogen from Table 1-1 in percent-	100 %	100 %	%	%
24. Nitrogen retained, in percent, after application from Table 1-2-	75 %	70 %	%	%
25. Calculate nitrogen availability- N line 3 x line 4 x line 5 ÷ 10,000=	lb/1000 gal 6.00	lb/ton 0.00	lb/1000 gal	lb/ton
26. Determine the amount of nitrogen and potassium applied from nutrient concentration data on line 3 and nutrient application charts: **Nitrogen (N)-**	lb/acre 85	lb/acre 0	lb/acre	lb/acre
Potassium (K_2O)-	169	0		
27. Total Nutrients Applied, lb/acre: **Nitrogen (N)-** (Sum of liquids and solids from line 8)	**85 lb/acre**			**lb/acre**
Phosphorus (P_2O_5)- (Sum of liquids and solids from line 2)	**57 lb/acre**			**lb/acre**
Potassium (K_2O)- (Sum of liquids and solids from line 8)	**169 lb/acre**			**lb/acre**

OPERATIONS

Phosphorus Based Waste Application for Wil-View Farms

Name:_____ Date:_____

Planned Application:

Pasture/Hay Land is being grown and the recommended nutrient application from the nutrient management section is 57 pounds of phosphorus (P_2O_5) per acre. A tractor spreader will be used to make a 57 pound application of phosphorus from the dry pack manure and bedding source that will not be incorporated.

Waste application rates and amounts:

Steps	Planned Application		Current Application	
	Liquid	Solids	Liquid	Solids
28. Crop receiving waste-	**Pasture/Hayland**			
29. Desired phosphorus application rate, lb/acre-	NA	57		
30. Nutrient concentrations in storage from laboratory analysis or from Table 1-1: **Nitrogen (N)-**	lb/1000 gal NA	lb/ton 9	lb/1000 gal	lb/ton
Phosphorus (P_2O_5)-	NA	4		
Potassium (K_2O)-	NA	19		
31. Determine phosphorus application rate from the nutrient application charts: **Phosphorus (P_2O_5)-**	inches/acre 0.00	tons/acre 14	inches/acre	tons/acre
32. Plant availability of nitrogen from Table 1-1 in percent-	100 %	100 %	%	%
33. Nitrogen retained, in percent, after application from Table 1-2-	75 %	70 %	%	%
34. Calculate nitrogen availability- N line 3 x line 4 x line 5 ÷ 10,000=	lb/1000 gal 0.00	lb/ton 6.30	lb/1000 gal	lb/ton
35. Determine the amount of nitrogen and potassium applied from nutrient concentration data on line 3 and nutrient application charts: **Nitrogen (N)-**	lb/acre 0	lb/acre 88	lb/acre	lb/acre
Potassium (K_2O)-	0	266		
36. Total Nutrients Applied, lb/acre: **Nitrogen (N)-** (Sum of liquids and solids from line 8)	**88 lb/acre**			**lb/acre**
Phosphorus (P_2O_5)- (Sum of liquids and solids from line 2)	**57 lb/acre**			**lb/acre**
Potassium (K_2O)- (Sum of liquids and solids from line 8)	**266 lb/acre**			**lb/acre**

OPERATIONS

Table 1-1
Typical Manure Nutrient Concentrations for Different Handling Systems

The table below shows typical values of the nutrient content of manure from different animal waste handling systems. You can use them as a rough estimate of the nutrient content of your manure. Because manure nutrient content varies widely among farms and even over time on the same farm, it is recommended to test your manure to get realistic nutrient content numbers for your farm. Refer to Pacific Northwest Extention Publication PNW 505 "Which Test is Best?" located in Section 13 for guidance in sampling and testing manure.

Typical nutrient content, solids content, moisture content, density, and nitrogen availability of animal manure at the time of application:							
Solids from:	**Nitrogen N** (lb/Ton)[2]	**Phosphorus P_2O_5** (lb/Ton)[2]	**Potassium K_2O** (lb/Ton)[2]	**Solids** (Percent)	**Typical Moisture** (Percent)	**Bulk Density** (lb/cubic yard)	**Nitrogen Availability** (Percent)[1]
Broiler with litter	73	64	66	70	30	900	40-70
Laying Hen	37	57	47	40	60	1,400	40-70
Sheep	18	9	35	28	72	1,400	25-50
Horse	9	6	16	37	63	1,400	0-20
Beef	12	6	17	23	77	1,400	20-40
Dairy:							
Dry Stack	9	4	19	35	65	1,400	20-40
Separated Solids	5	2	3	19	81	1,100	0-20
Liquids from:	**Nitrogen N** (lb/1,000gal)	**Phosphorus P_2O_5** (lb/1,000gal)	**Potassium K_2O** (lb/1,000gal)	**Solids** (Percent)	**Typical Moisture** (Percent)	**Density** (lb/gal)	**Nitrogen Availability** (Percent)[1]
Dairy:							
Holding Tank	21	14	24	8	92	9.2	30-60
Pond, no agitation	4	1	6	<1	>99	8.4	60-90
Pond, agitated	12	7	18	4	96	9.0	30-60

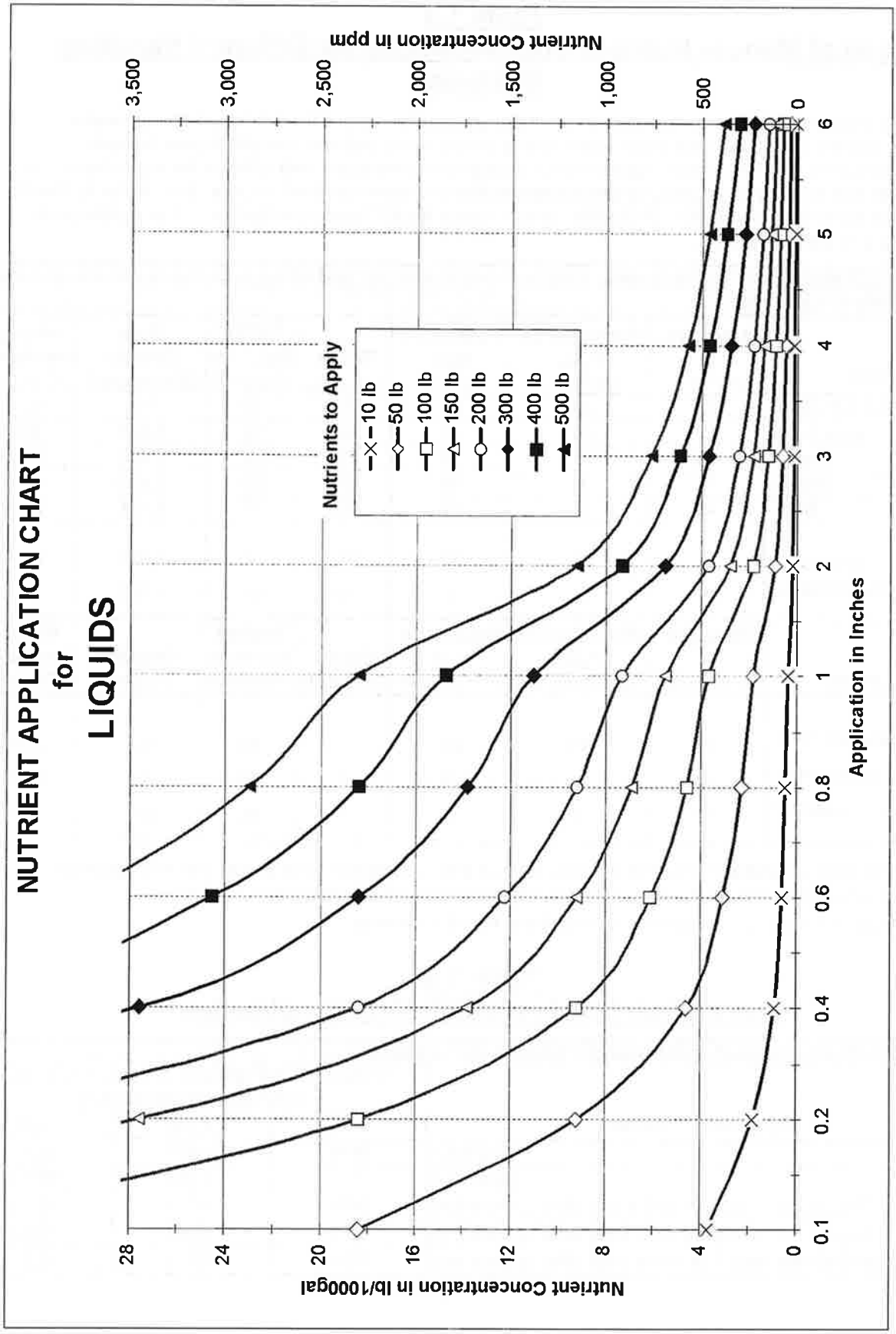
[1] Nitrogen available in the first growing season after application. For a field that has received manure annually for 4 years or more, consider 100% of the nitrogen available.

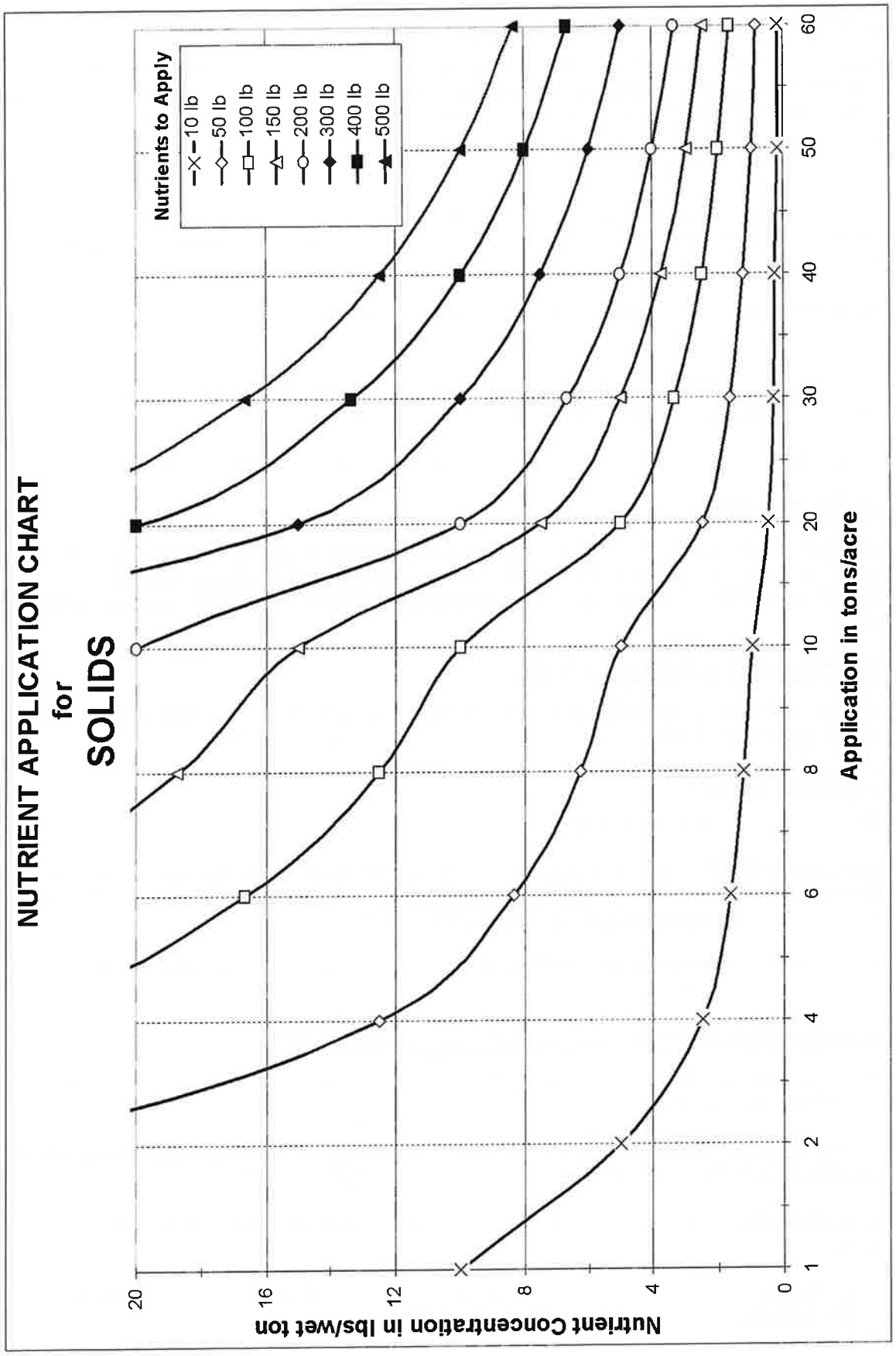
[2] Manure is at the moisture content typically found in storage.

Table 1-2
Typical Nutrient Availability After Application

Typical nutrient content of animal manure retained after application:			
Application Method	Percent of original nutrient content of manure retained after application		
	N	**P_2O_5**	**K_2O**
Injection	95%	100%	100%
Sprinkling	75%	100%	100%
Broadcast (Incorporated 1 day after application)	90%	100%	100%
Broadcast (Incorporated 4 days after application)	80%	100%	100%
Broadcast (Incorporated 7 or more days after application)	70%	100%	100%

OPERATIONS


NUTRIENT APPLICATION CHART
for
LIQUIDS
Nutrient Concentration in ppm
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Nutrient Concentration in lb/1000gal
28
24
20
16
12
8
4
0
Application in Inches
0.1
0.2
0.4
0.6
0.8
1
2
3
4
5
6
Nutrients to Apply
10 lb
50 lb
100 lb
150 lb
200 lb
300 lb
400 lb
500 lb


NUTRIENT APPLICATION CHART
for
SOLIDS
Nutrients to Apply
10 lb
50 lb
100 lb
150 lb
200 lb
300 lb
400 lb
500 lb
Nutrient Concentration in lbs/wet ton
0
4
8
12
16
20
Application in tons/acre
1
2
4
6
8
10
20
30
40
50
60

OPERATIONS

ACCESS ROADS, LOTS AND WALKWAYS (PS560, PS561, PS575)

Maintain road, parking lot and pathway surfaces in good condition, which includes periodic grading and addition of surface material when necessary. Prevent surface ponding by localized grading or addition of surface materials to remove depressions. Road base-course rock may be required to stabilize the road and parking lot foundations. If so, remove unstable materials and rebuild travelway. Limit traffic and animal access with fencing or barriers, where needed.

Remove debris, litter or blockages from roads, parking lots and walkways. Also remove debris and maintain capacity of associated drainage ditches, drop inlets, culverts, bridges, waterways and storm water outlets.

Eradicate or otherwise remove all rodents or burrowing animals. Immediately repair any damage caused by their activity.

Immediately repair any vandalism, vehicular, or livestock damage to earthfills, side slopes, drainage facilities, water ways and storm water outlets or other appurtenances.

Maintain good vegetative cover, mulches, and other covering installed for erosion protection.

BUILDING ROOFS (PS313)

Inspect building roofs annually as a minimum. Repair and/or replace all rusted sections and secure loose sections as needed. Immediately replace all broken trusses, rafters, beams, poles as needed. Immediately determining the cause and necessary modification(s) to prevent reoccurring structural failure is essential.

DROP INLETS (CATCH BASINS) (PS587)

Remove debris and sediment from grates as needed. Annually inspect grates and receiving structures and repair or replace as necessary.

FENCES (PS382, PS472)

Limit access to designated areas as needed.

Inspect fences periodically and repair or replace broken or decayed posts and tighten sagging wire as needed. Broken wire can be spliced or replaced. Replace broken or missing insulators on electric fences as needed and repair or replace inoperative electric fence controllers.

Insure gates and other appurtenances are in good working order. Replace or repair components as needed.

LIQUID WASTE AND IRRIGATION PIPELINES (PS430, PS634)

Flush pipelines used for liquid waste applications with clean water following waste application, or as needed, to prevent particle buildup.

Drain the pipeline and components in areas that are subject to freezing. If parts of the pipeline cannot be drained, a non-toxic antifreeze solution may be added.

Check to make sure all valves and air vents are set at the proper operating condition so they can provide protection to the pipeline.

Inspect pipelines for signs of failure. Inspect risers and valves periodically for leaks or worn gaskets. Repair or replace pipeline, risers and valves as needed.

OPERATIONS

Drain the pipeline and components in areas that are subject to freezing. If parts of the pipeline cannot be drained, a non-toxic antifreeze solution may be added.

Eradicate or otherwise remove all rodents or burrowing animals. Immediately repair any damage caused by their activity.

PUMPS AND AGITATORS (PS533, PS634)

Operate and maintain pumps in accordance with good judgment and manufacture's manuals and recommendations.

Drain liquid manure from pumps during cold weather to prevent freezing. If parts of the system cannot be drained, a non-toxic antifreeze solution may be added.

Inspect pumps periodically and remove debris wrapped around shafts and impellers. Maintain foot valves and check valves for proper operation.

For proper operation of electric motors and controls, maintain lubrication for all bearings, keep electric panel free from obstructions and debris. Maintain electrical safety devices, assure all electrical contacts are tight, and lock main electrical switch to "OFF" position during non-use season. Maintain adequate shade and ventilation for pump motors.

For proper operation of pumps, maintain lubrication for all bearings and pump shafts, assure belts are adjusted properly, maintain safety covering devices on open shafts and belt drives, check to make sure all safety valves and devices are set at proper operating conditions so they may provide protection to the pump and power unit. For centrifugal pumps, periodically measure tolerance between pump impeller and pump casing (i.e. wearing) and replace wear ring as needed to help restore new pump operating characteristics.

Use portable pressure gauge (preferably a liquid filled gauge) to monitor pump performance.

Operate and maintain agitators in accordance with the manufacture's manual and recommendations. Inspect all plumbing annually as a minimum.

Replace, tighten, or repair broken or loose connections and lines as needed.

RAIN GUTTERS AND DOWNSPOUTS (PS558)

Annually inspect rain gutters, downspouts, pipelines, trash guards, pumps, structures and appurtances for proper operation. Keep them free of all foreign material, weeds and sediment. Repair or replace any damaged component as needed.

Keep downspouts and outlets free flowing. Repair or replace broken rodent guards as needed. If hydraulic capacity is insufficient, replace gutters (and downspouts if needed or make provisions for the waste management system to handle the extra water.

Protect downspouts from damage by livestock and equipment and repair any damaged components as needed.

SLABS AND CURBS (PS561, PS634)

Periodically inspect concrete and asphalt slabs and curbs and repair or replace broken sections as needed. Prevent manure from building up next to the curbs or over topping them.

OPERATIONS

SPRINKLER IRRIGATION SYSTEM (PS442)

Maintain traveling gun type sprinklers (and hose reel, if used) by oiling and greasing moving parts and the engine in accordance with the manufacturer's recommendations to help ensure trouble free operation. Prevent livestock access to equipment during operation.

Clean plugged nozzles and replace if worn or defective.

Promptly repair all leaks by replacing valves, fittings, gaskets, worn or damaged parts.

STREAM CROSSINGS (PS578)

The stream crossing, appurtenances, and associated fence should be inspected after each major storm event, with repairs made as needed.

UNDERGROUND OUTLETS (PS620)

Annually inspect underground outlets for proper operation. Check fields for signs of positive pressure (blow holes) or negative pressure (sink holes) in underground pipelines. Repair or replace damaged or broken pipelines as needed maintaining designed depth of cover.

Keep outlets free of vegetation and sediment. Correct and prevent erosion at outlets by installing riprap or other measures. Repair or replace damaged or broken rodent guards as needed.

Avoid travel over underground pipelines with heavy equipment when the soil is saturated except at crossings designed for this purpose.

Avoid any subsoiling operation that may disturb the underground outlet.

Eradicate or otherwise remove all rodents and/or burrowing animals that have or can potentially damage any part of the system. Immediately repair any damage caused by their activity.

Immediately repair any damage due to vandalism, vehicular or livestock.

WASTE STORAGE FACILITIES (PS313)

WASTEWATER STORAGE PONDS-

The two cell waste storage pond shown on the facility map has a design capacity of 18.6 acre feet to store liquid manure and polluted runoff for a period of October to April.

The waste storage pond will serve as the primary storage facility for wastewater produced from the operation. Emptying of the waste storage pond should begin in late February before the pond is completely filled. Emptying should continue through the spring and summer months as weather conditions permit applying liquids in accordance with the guidance given the nutrient and waste utilization parts of this section. To function properly and have the greatest management flexibility, the waste storage pond must be as empty as possible in October before the fall and winter rainy season begins.

Cell #1 of the waste storage pond serves as a settling basin to capture solids before they are transferred to Cell #2. It is important that Cell #1 be agitated and as many of the solids removed as possible without disturbing the bottom and sides of the facility. All solids removed from the waste storage pond should be transported off farm for utilization to reduce on farm phosphorus applications.

Do not permit livestock access to the pond or on pond embankments. Control undesirable vegetation growth by spraying or mowing. Control rodents as necessary. Check elevations of earthfills periodically and restored to grade and shape as necessary. Fill and reseed eroded embankment areas or repair with well graded rock riprap. Repair embankment leaks immediately should they occur. Safety features such as signs and fences should be kept in good repair.

OPERATIONS

Maintain at least 2 feet of freeboard in the pond to prevent embankment overtopping and subsequent embankment erosion.

WASTEWATER STORAGE TANKS-
Pump liquid and solid waste collected in the tanks to the long term storage facility to prevent overtopping of tanks. During periods of heavy rainfall events, when a temporary ground water table may be present, do not pump the tanks to a depth more than three feet below the level of the water table.

Do not allow equipment that exceeds the design limit of the tanks on or within twenty feet of the structure. Keep pumps, agitators, piping, valves and all other electrical and mechanical equipment in good condition by following the manufacturer's recommendations. Maintain grounding rods and wiring for all electrical equipment in good condition.

Maintain all fences, railings, and/or warning signs to provide warning and/or prevent unauthorized human or livestock entry. Immediately repair vandalism, vehicular or livestock damage to the structure, earthen areas surrounding the structure, or any appurtenances. Maintain lids, grates and shields on openings.

Immediately remove all foreign debris within the structure that may cause damage to pumps or agitators.

Provide proper ventilation before entering the tank, for any reason what so ever. Provide and use self - contained breathing apparatus (scuba) equipment when entering a tank. No persons should enter the tank unless safety ropes are used and someone else capable of providing rescue assistance is outside the tank.

Do not assume any storage tank, including open top storage tanks, are well ventilated.

SOLIDS STORAGE FACILITY-
The solids storage facility shown on the facility map has a design capacity of 21,000 cubic feet or 536 tons to store manure, bedding and other organic waste for a period of November to March.

The solids storage facility will serve as the primary storage facility for manure, bedding and other organic waste produced from the operation. Emptying of the solids storage facility should begin as early as possible in the spring. Emptying should continue through the spring and summer months as weather conditions permit applying solids in accordance with the guidance given the nutrient and waste utilization parts of this section. To function properly and have the greatest management flexibility, the solids storage facility must be as empty as possible in October before the fall and winter rainy season begins. The solids storage facility is designed as a 60 foot by 140 foot reinforced concrete slab which will allow the solids to be stacked to a height of 8 feet. At no time should the solids be allowed to spill outside off of the slab area.

CURBS AROUND STRUCTURE ?

Periodically inspect concrete and asphalt slabs, walls and curbs and repair or replace broken sections as needed. Cleanup any spillage of manure and organics from outside of the solids storage area and place them back in the solids storage facility.

Maintain all fences, railings, and/or warning signs to provide warning and/or prevent unauthorized human or livestock entry. Immediately repair vandalism, vehicular or livestock damage to the structure, earthen areas surrounding the structure, or any appurtenances.

WATERING FACILITIES (PS614)

Check all above ground connections, valves, gates, rodent guards, inlets and outlets to make sure they are functioning properly. Check troughs and tanks for leaks or cracks and repair or replace immediately, if necessary.

OPERATIONS

Make certain the area adjacent to the trough is well protected with gravel, paving, or good cover. Be sure that the outlet pipe has a free outlet and is not causing any serious erosion problems. Check periodically to see if debris has fallen into the trough or tank which may restrict inflow or planned functions of the outflow system.

Clean the entire system periodically and remove moss, algae growth, and/or sludge. Chemicals such as copper sulfate and chlorine can be used to prevent moss and algae growth. Local rules and regulations are to be followed when using chemicals to make sure they are safe for animals.

Where necessary maintain coverings and insulation to prevent damage by freezing.

Eradicate or otherwise remove all rodents or burrowing animals. Immediately repair any damage caused by their activity.

Immediately repair any vandalism, vehicular or livestock damage.

WELLS (PS642)

Protect the area immediately surrounding the well from being damaged by agriculture machinery, vehicles, or livestock.

All fences, railings, and/or warning signs shall be maintained to provide warning and/or prevent unauthorized human or livestock entry.

Do not allow any foreign debris to accumulate and maintain soil and vegetative covering in the immediate vicinity of the well.

Eradicate or otherwise remove all rodents or burrowing animals. Immediately repair any damage caused by their activity.

Check metal surfaces for rust and other damage especially sections in contact with earthfill and with other materials. Repair or replace damaged section and apply paint as a protective covering.

Keep all surface water from entering or accumulating at the immediate vicinity of the well site. Immediately repair any vandalism, vehicular, or livestock damage.

RECORD KEEPING

Records are to be kept for a minimum of 5 years or the length of the cropping rotation, whichever is longer. The AFOPro software used to generate this plan has a utility for keeping records associated with this plan or copies of the worksheets provided in this section can be used to keep records. Records shall include the following information:

1. Annual Manure Testing (Refer to Pacific Northwest Extention Publication PNW 505 "Which Test is Best?" located in Section 13 for guidance in sampling and testing manure).
2. Soil test results (Refer to Pacific Northwest Extention Publication PNW 570-E "Monitoring Soil Nutrients Using a Management Unit Approach" located in Section 13 for guidance in soil testing).
3. Application Records for each manure, wastewater or commercial fertilizer application event, including:
   - ❑ Containment source or type and form of commercial fertilizer,
   - ❑ Field(s) where manure or organic by-products are applied,
   - ❑ Amount of manure solids and wastewater applied per acre,
   - ❑ Calculations of nutrients applied per acre (see worksheets in Section 8),
   - ❑ Time and date of application,
   - ❑ Weather conditions during nutrient applications,
   - ❑ General soil moisture conditions and time of application (i.e., saturated, wet, moist, dry), and
   - ❑ Application method and equipment used.
4. Crops planted and planting and/or harvesting dates, by field.
5. Records that address manure and wastewater storage containment structures:
   - ❑ Dates of emptying, level before emptying and level after emptying,
   - ❑ Discharges or overflow events, including level before and after event.
6. Transfer of manure and organic by-products off-farm or to third parties:
   - ❑ Manure solids and wastewater nutrient content,
   - ❑ Amount of manure solids and wastewater transferred,
   - ❑ Date of transfer, and
   - ❑ Recipient of manure solids, wastewater or organic by-products.
7. Activities associated with emergency spill response plan.
8. Records associated with any reviews by NRCS, third-party consultants, or representatives of regulatory agencies:
   - ❑ Dates of review,
   - ❑ Name of reviewer and purpose of the review,
   - ❑ Recommendations or follow-up requirements resulting from the review, and
   - ❑ Actions taken as a result of the review.
9. Records of maintenance performed associated with operation and maintenance plans (Refer to guidance in the Operations section on Operation and Maintenance of facilities).
10. Nutrient application equipment calibrations (Refer to guidance in the Operations section on Waste Utilization).
11. Changes made to this plan.

RECORD KEEPING

Annual Manure Testing Worksheet for Wil-View Farms

Date	Name of Person Who Took Sample	Source (Pond, Drystack etc)	Nutrient Concentration (lbs/1000 gal or lbs/ton) N	P_2O_5	K_2O

NOTES:

Refer to Pacific Section 8, Waste Application and Utilization, for guidance in sampling and testing manure.

RECORD KEEPING

Soil Sampling Worksheet for Wil-View Farms

Name of Person Who Sampled Soils: _____ **Date:** _____

Tract number:		**Field Number(s):**		**Total Acres:**	
Current Crop:		**Yield Goal:**			

Soil Test Information

Soil Test ID	Soil Test Results (ppm) N	P	K	pH	% Organic Matter	Other [ ]

NOTES:

Refer to Pacific Northwest Extension Publication PNW 570-E "Monitoring Soil Nutrients Using a Management Unit Approach" located in Section 13 for guidance in soil testing.

RECORD KEEPING

Field Application Worksheet for Wil-View Farms

Name: _____ **Date:** _____

Tract number:		**Field Number(s):**		**Total Acres:**	
Current Crop:		**Yield Goal(s):**		**Soil Moisture Condition:** (Saturated, Wet, Moist or Dry)	

Soil and Organic Test Information

Soil Sample ID	Soil Test Results (ppm) N	P	K	Other	Organic Test (Source)	Organic Test Results (lbs/ton, lbs/1000 gal) N	P_2O_5	K_2O

Nutrient Application

Date/Time	Nutrient Source (fertilizer, manure)	Gross Applied (per acre)	Units* (lbs, tons, ac-in)	Formulation* N	P_2O_5	K_2O	Net Applied (lbs/acre) N	P_2O_5	K_2O
					Totals				

* Units and Formulations must be consistent. For commercial fertilizer, units should be lbs and formulation should be %. For solid manure, units should be tons and formulation should be lbs/ton. For liquid manure, units should be ac-in and formulation should be lbs/1000 gal.

RECORD KEEPING

Off-Farm Transfer Worksheet for Wil-View Farms

Transferred To: (Name)	Date	Amount (tons or Gallons)	Nutrient Content N	P	K

NOTES:

RECORD KEEPING

Spill Log for Wil-View Farms

Date	Source of Spill	Report filed with ODA (Yes/No)	Cleanup Completed by:	Date

NOTES:

See following dated spill report for details of spills.

RECORD KEEPING

Record of Plan Reviews and Changes for Wil-View Farms

Date	Name of Reviewer	Changes to plan needed (Yes/No)	Actions Completed by:	Date

NOTES:

See following dated reports of reviews and changes made to this plan.

RECORD KEEPING

Record of Operation and Maintenance Inspections for Wil-View Farms

Date	Name of Inspector	Corrective Actions Needed (Yes/No)	Actions Completed by:	Date

NOTES:

See Operation and Maintenance guidelines in the Operations section for action items. Record corrective actions needed and taken under notes.

RECORD KEEPING

Record of Application Equipment Calibration for Wil-View Farms

Date	Equipment Calibrated	Equipment Calibrated by:

NOTES:

Refer to worksheets in the Operations section for Waste Utilization for guidance in calibrating equipment. File copies of worksheets behind this sheet.

RECORD KEEPING

PNW 570-E • October 2003

Monitoring Soil Nutrients Using a Management Unit Approach

M.L. Staben, J.W. Ellsworth, D.M. Sullivan, D. Horneck, B.D. Brown, and R.G. Stevens

What's in this publication?

This publication focuses on how to design a soil nutrient monitoring strategy that fits today's requirements for record keeping and increased accuracy in managing nitrogen (N), phosphorus (P), and other nutrients. We advocate the use of management units or zones for soil testing and nutrient application. To measure a real change in soil test values over time, you will need to use consistent management units over many growing seasons.

In this publication, a management unit is considered an area in a field that is soil-sampled and fertilized separately for one or more nutrients. Different management unit delineations may be more appropriate for insect, weed, and disease control; irrigation water management; and other cultural practices.

The management unit approach is designed to provide better information to make nutrient management decisions at a reasonable cost. This approach combines the ease of traditional whole-field sampling and the power of an intensive grid sampling method (see pages 2–3). With a management unit approach, a grower can vary the amount and type of nutrient applications within a field without the need for grid sampling.

A monitoring strategy will answer only the questions it was designed to answer. Each field will have a specific soil sampling strategy. Key questions to consider when developing a soil testing strategy for nutrient management are discussed in this publication, including time of sampling, depth of sampling, number of subsamples, and location for sampling in the management unit.

A soil sampling protocol designed to measure changes in soil nutrient status over time must minimize random variability in soil test results. This is especially important when soil sampling is part of a required nutrient management plan. This publication suggests strategies for minimizing random variability.

Two examples of nutrient monitoring are provided to illustrate the process of deciding when, where, and how to sample, as well as how to interpret the soil test results. One example uses reference sampling areas

Mary L. Staben, Extension educator, Oregon State University; Jason W. Ellsworth, Extension soil scientist, University of Idaho; Dan M. Sullivan, Extension soil scientist, Oregon State University; Donald Horneck, Extension agronomist, Oregon State University; Bradford D. Brown, Extension crop management specialist, University of Idaho; Robert G. Stevens, Extension soil scientist, Washington State University.

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within management units, and the other uses random sampling throughout the management unit. These examples are intended to illustrate the process of using management units to make nutrient management decisions.

What are the advantages of the management unit approach?

The sidebars on this page and the following page describe two approaches to sampling: whole-field sampling and grid sampling. Each sampling strategy has limitations that can be overcome by adopting a management unit approach, as described in this publication.

The goal of using a management unit approach is to save money, and often time, compared to grid-based sampling methods, while obtaining more accurate data than that provided by whole-field sampling. The management unit approach is designed to provide many of the benefits of grid sampling while overcoming its high cost and other limitations. In many cases, this process allows growers to make fertilizer or amendment applications without the use of global positioning system (GPS) units and expensive variable-rate controllers.

Developing and using management units can allow a producer to apply amendments in varying amounts within a field. Higher levels of a particular nutrient can be applied in areas of the field that are likely to respond or have not reached a critical limit, while less or none can be applied in areas that have higher values and are less likely to respond. In most cases, this type of sampling plan satisfies many regulatory requirements while allowing the crop to be managed in a reasonable way.

Whole-field sampling

The whole-field soil sampling approach is a simple protocol used for many cropping systems. Soil cores are collected from the entire field, mixed together, and a single composite sample is sent to a laboratory for analysis.

The problem with whole-field sampling is that it treats the entire field the same regardless of differences in landscape position, soil characteristics, or cropping history. Thus, conclusions drawn from the soil test may not be appropriate for each part of the field. Often, average nutrient levels are found in only a small part of the field. The rest of the field is either higher or lower than the average. Basing fertilizer application on the field average means that some areas will be overfertilized and others will be underfertilized.

What criteria are used to divide a field into management units?

When deciding how to divide a field into management units, both soil features and the grower's needs and priorities for managing each field should be considered. The goal is to divide fields into areas that are more uniform than the field as a whole.

The basis for consideration can include inherent variability (soil texture, topography, mineralogy, drainage, soil test values), variability associated with current management (tillage, irrigation water distribution), and historical variability (previous crop yields, manure application, field leveling, old fence lines) within a field. The minimum size of a management unit should be defined by equipment size, so that each management unit is large enough to be fertilized separately.

Grid sampling

The most accurate picture of the characteristics of a field would be produced by sampling every point within the field. Since it is impractical to do so, grid sampling can be used as an improvement over whole-field sampling. First, a field is systematically divided into areas of uniform size and shape (called cells) to form a grid. Cells often consist of 1 to 5 acres. Then, samples (consisting of a composite of 10 or more cores) are taken from each cell and analyzed. Thus, each cell has its own sample and analysis result.

The purpose of grid sampling is to create a detailed map of the field that allows the grower to identify areas that will receive a unique management practice. Using software that estimates soil test results between cells, patterns of estimated nutrient availability can be determined and a nutrient application map created.

The main challenge of grid sampling is its expense. A 125-acre field can have as many as 125 individual samples (if the field is divided into 1-acre cells). On a farm of several hundred acres, the cost of sampling (labor and equipment) and lab fees can become prohibitive. On the other hand, some labs give a substantial discount to growers who grid sample.

Grid sampling does not need to be done every year for most soil tests. The cost could be spread over a rotation by sampling intensively before one crop to create management units and then taking a few samples in subsequent years to verify the spatial patterns of soil nutrients.

Another limitation to grid sampling is that the grid spacing chosen may either obscure or exaggerate variability caused by a regular pattern such as wheel rows or movable sprinkler lines. However, modified versions of grid sampling patterns can overcome this potential weakness.

Dividing a field into management units is a combination of art and science. The management unit approach for soil sampling described in this publication enables growers to use their knowledge of the field to help define management units. Often, management units can be delineated on the basis of soil color or other landscape features that are easy to identify visually.

Certain field features, such as areas where soil was removed for field leveling, are not clearly delineated on most maps. However, you might be able to obtain cut-and-fill maps from the operator who did the leveling. Such maps can be quite useful in delineating nutrient management units.

Consider using other sources of information to delineate management units. Maps produced from remote sensing data (e.g., aerial photos or satellite imagery) and yield monitors are useful visual aids. Other tools include geographic information systems (GIS) software and GPS units.

Time and skill are required to manipulate the raw map data into a format that allows overlay of maps for the same field. After a multiple layer map is created, many factors can be considered simultaneously to delineate management units. These maps are also useful for recording soil sampling locations within the field.

Where should I collect soil samples from within a management unit?

Collect soil cores throughout each management unit (unit sampling) or from a smaller reference sampling area within a management unit (Figure 1). Select one of these approaches, and use it consistently.

In the center-pivot irrigated field shown in Figure 1, each of the three management units is delineated by one or more soil properties or management practices. For example, Management Unit 1 may be an eroded hilltop, Management Unit 2 may consist of side slopes with shallow topsoil, and Management Unit 3 may consist of bottomlands with poor drainage and high organic matter. The sampling plan for the field on the left (A) uses a zigzag pattern to collect subsamples, or cores, across the entire management unit. Soil cores collected within each management unit are composited into one sample for that management unit. In the field on the right (B), reference sampling areas are established away from the edges of the field but near access points such as the pivot road.

The sampling location for each core may or may not be recorded (georeferenced).

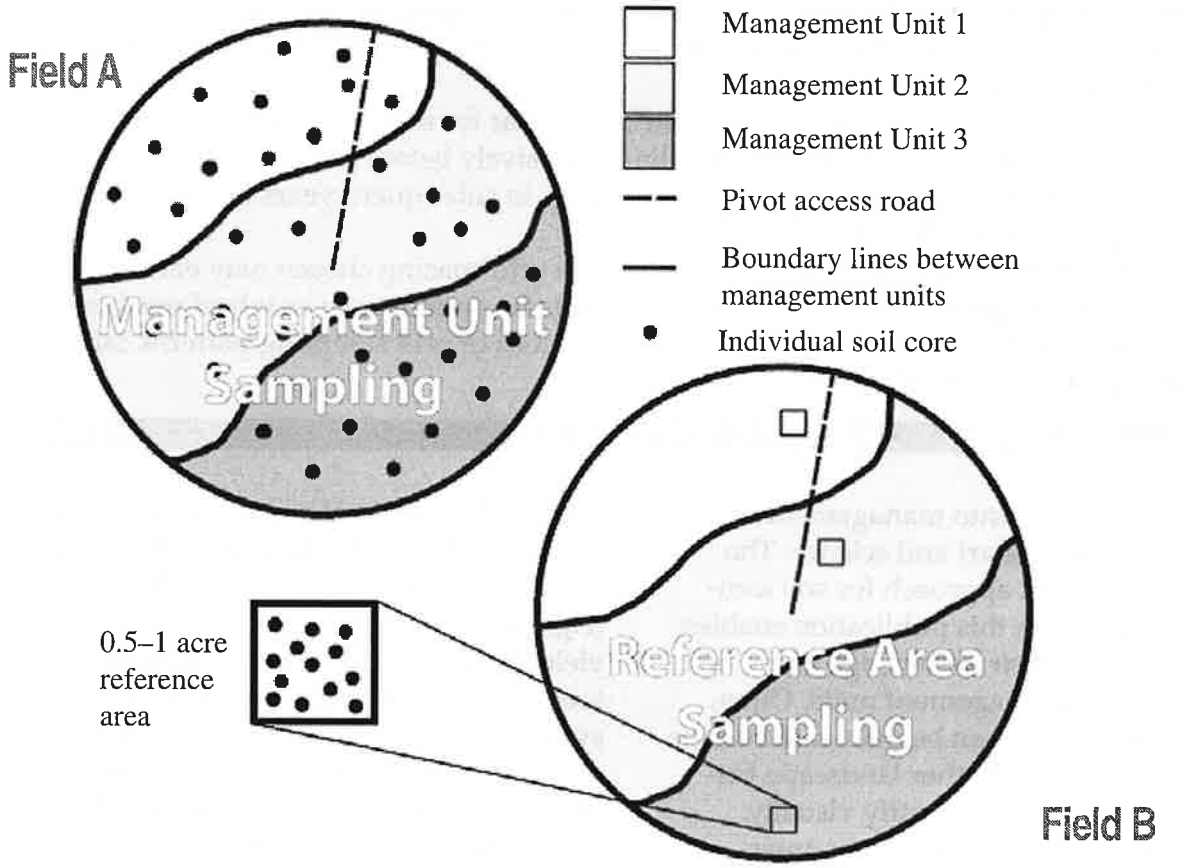

Figure 1.—Aerial view of two fields with a center-pivot overhead sprinkler irrigation system that have been divided into three management units. The top left field (A) illustrates a random sampling approach for sampling within each management unit. The lower right field (B) illustrates the reference sampling area approach for sampling within each management unit.

The benefit of georeferencing sampling locations is that in subsequent years you can return to the same areas with some degree of accuracy and minimize year-to-year variability. Georeferencing commonly is done with a GPS unit. Currently, the least expensive units can be accurate to ± 15 to 20 feet, under ideal conditions. Alternatively, it may be possible to install markers in the field that will withstand farming practices, allowing them to be found for future sampling.

For either the unit or reference sampling approach, avoid collecting samples from small, atypical areas such as animal feeding areas, gate and watering areas, corral and home sites, old roads, field edges, and eroded hilltops. It might be useful to analyze such samples separately for possible consideration as separate management units.

Management unit sampling approach

Take individual soil cores (10 or more) randomly over the entire management unit and mix them into a composite (Figure 1a).

Advantages of sampling randomly within management units include:

- One sample represents the entire management unit.
- Likely to provide better data than the reference sampling area approach when uniformity in soil or management practices (e.g., manure application) is uncertain.

Disadvantages of sampling randomly within management units include:

- Sample collection requires more time compared to sample collection by the reference sampling area approach (described at right).
- Heavy sampling equipment, if required, must be moved across the management unit.

Reference sampling area approach

Reference sampling areas are smaller sampling areas within a management unit. They can be used for representative soil sampling and other crop monitoring activities, such as plant tissue sampling, soil moisture measurement, or crop yield estimates. This method is most beneficial when heavy sampling equipment is used or when the management unit is very uniform.

The intensity of management and variability of the field should dictate how large an area can be represented by one reference sampling area. A local expert (university Extension personnel; private certified crop advisor, agronomist, or soil scientist; or Natural Resources Conservation Service personnel) can be consulted to assist you in determining what might be appropriate for your situation.

Reference sampling areas should be representative of the entire management unit and easy to access. To make sure a reference sampling area is representative, compare soil test values from proposed reference sampling area(s) with soil test values for a composite sample taken from the entire management unit (see "Management unit sampling approach").

Within each management unit, select an area of 0.5 to 1 acre for each reference sampling area (Figure 1b). Plan to georeference the four corners of the sampling area to minimize year-to-year variability. Ways to georeference reference sampling areas, besides using GPS, include using specific tree numbers in an orchard, measuring the distance from a fence or fixed equipment, or installing markers.

Advantages of reference sampling areas include the following.

- Fields can be sampled more quickly.
- It is easier to georeference sampling locations.

- You can use more than one reference sampling area within a management unit to allow for differences in known management variables (e.g., irrigation water distribution).
- There is more year-to-year consistency due to less spatial variability.

Disadvantages of reference sampling areas include the following.

- The reference sampling area may not represent the management unit as a whole.
- If georeference coordinates or field markers are lost, the exact location of the reference sampling area may be lost.
- Heavy traffic within the reference area may occur if care is not taken.
- The sampling area will be compromised if a nutrient or other amendment spill occurs within the reference sampling area.

The reference sampling area approach often is used for in-season testing for soil nitrate, because:

- More soil cores can be collected in a given amount of time.
- Fixed soil moisture monitoring sites (e.g., neutron probe) can be located within the same reference sampling area.
- Reduced sampling equipment traffic over the field reduces crop damage and soil compaction.

How to develop a plan for soil nutrient monitoring

Soil test data will answer only the questions the test was designed to answer. The following steps and questions can help you design a monitoring system tailored to your needs (Table 1). Two examples of how to develop a plan are included (see Examples 1 and 2, pages 10–13).

Table 1.—Considerations and questions for designing a soil nutrient monitoring plan.

Soil monitoring considerations	Specific questions
Objectives	• What is (are) your objective(s) for nutrient monitoring? • What nutrients or other soil chemical properties do you want to measure? • Are you required by any agreement to monitor specific nutrients or soil chemical properties?
Where to sample	• Should you collect samples throughout the management unit, or use a reference sampling area? • Do you plan to georeference locations where soil cores are collected? • What method will you use to georeference sampling locations?
How to sample	• When should samples be collected? • What soil sampling depth(s) are appropriate? • How many soil cores will be collected for each composite sample sent to a laboratory for analysis? • Should you sample using a zigzag approach or a systematic sampling method within the sampling area?

Table 2.—Typical frequency for assessment of changes in soil test values.

As needed for specific cropping system	Annually**	Periodic (once per crop rotation or every 3 to 5 years)	Once, if necessary, for initial site assessment
Nitrate-N (NO_3-N)*: preplant, in-season, or postharvest	extractable boron (B), total or sulfate-sulfur (S)***, electrical conductivity (EC)	pH, lime requirement, Bray or Olsen P, extractable bases (K, Ca, Mg, Na), extractable micronutrients (DTPA-Zn, Mn, Cu, Fe)	soil texture, cation exchange capacity (CEC), organic matter

* Soil testing frequency for nitrate-N varies widely for different cropping systems.

** For cropping systems with high-sodium (Na) irrigation water, an annual test for sodium absorption ratio (SAR) is recommended. The SAR test includes determination of exchangeable calcium (Ca), magnesium (Mg), and sodium (Na).

*** For sulfur (S), plant-tissue testing is preferred over soil testing. Soil test sulfur (sulfate-S or total S) is not a good predictor of crop yield response to S fertilizer in many situations.

Objectives

Think carefully about your objectives. Soil testing can be used just to monitor nutrient levels for record-keeping requirements, or it can be used to guide nutrient application decisions. Agricultural professionals (university Extension personnel; private certified crop advisors, agronomists, or soil scientists; and Natural Resources Conservation Service personnel) often can help in designing a customized sampling strategy.

What nutrients or other soil chemical properties do you want to measure?

Soil tests that provide useful information for nutrient management purposes are listed in Table 2.

One of the goals of a soil testing program may be to avoid excessive application of nutrients or salts. Repeated application of organic materials, such as compost, manure, or biosolids, typically results in buildup of one or more nutrients, and possibly soluble salts. As an example, if manure application rates are based on supplying enough N for the crop, other nutrients (e.g., phosphorus and potassium) usually are added at rates greater than crop utilization. Soil testing can be used to track nutrient accumulation over time.

Because each organic material (e.g., manure, biosolids, compost) contains a unique balance of nutrients, a nutrient analysis of the organic material often is helpful in deciding which soil tests are appropriate. General information about the nutrient concentrations present in various organic materials can be found in Extension publications (see "For more information").

Several tests commonly offered by agricultural testing laboratories—organic matter, ammonium-N (NH_4-N), and sulfur (S)—are less useful in assessing management effects on soil fertility. Their shortcomings are discussed briefly here.

Soil sampling for ammonium-N (NH_4-N) is not recommended unless fertilizer or other organic amendments have been applied during the past 30 days, or if soil has remained dry or cold since N application. In most situations, ammonium-N is rapidly converted to nitrate-N (NO_3-N) in soil.

Soil organic matter testing often is part of a "routine" soil test, but it has limited value for nutrient management. Most fertilizer guides for irrigated crops do not use soil organic matter as a basis for nutrient management recommendations. (Some dryland fertilizer guides use soil organic matter values to adjust N recommendations.)

Soil organic matter content changes very slowly in response to management changes (tillage or organic amendment addition). Annual testing of soil organic matter is not recommended because random measurement error usually obscures small changes in organic matter content over time. Periodic soil organic matter testing (once per crop rotation or every 5 years) may be useful in measuring the impact of long-term management changes that are expected to build soil organic matter.

For sulfur (S), plant-tissue testing is preferred over soil testing. Soil test sulfur (sulfate-S or total S) is not a good predictor of crop yield response to S fertilizer in many situations.

Are you required by any agreement to monitor specific nutrients or soil chemical properties?

Nutrient management plans required by state or federal agencies often specify required soil analyses and sampling frequency. At a minimum, a sampling plan should meet agency requirements (if applicable). For example, landowners who participate in the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) for nutrient management often are required to collect soil test data according to NRCS specifications.

Where to sample

Collect soil cores throughout each management unit (unit sampling) or from a reference sampling area within each management unit, as discussed previously in "Where should I collect soil samples from within a management unit?"

How to sample

When should samples be collected?

The recommended sampling frequency is based on the rate of change in soil test values over time (Table 2). Tests for soil characteristics that do not change greatly in response to fertilizer or organic amendment addition (e.g., soil texture and cation exchange capacity) often are not necessary.

Timing of soil sampling is most critical for nitrate-nitrogen, because this form of N is mobile in soil water. Generally, it is best to collect soil samples for nitrate-N analysis close to N fertilizer application time.

Soil tests for soil characteristics that change slowly in response to management (periodic soil tests in Table 2) are recommended once per crop rotation or every 3 to 5 years. For these tests, small variations occur seasonally due to soil biological processes, crop residue decomposition, soil water status, and tillage. In determining management effects on these soil test values, develop a consistent protocol for the timing of sample collection.

What soil sampling depth(s) are appropriate?

Consult university fertilizer guides or nutrient management guides for the crop. Determine the soil sampling depth and any other special considerations for soil sampling in a particular cropping system. For many agronomic crops, interpretive tables

for soil test values are based on a sample taken to a 0- to 6-inch or a 0- to 12-inch depth. However, some N recommendations are based on sample depths up to 24 or 48 inches.

Using shallower sampling depths, in some cases, can allow for the detection of changes in soil nutrient status before they would be detected using a traditional sampling depth (6 or 12 inches). For pastures and some perennial crops where tillage is absent, nutrients with limited mobility (e.g., P and K) may accumulate near the soil surface. Sampling closer to the soil surface increases the probability of detecting changes in soil test values over time.

In some cases it is useful to split a sample by depth. For example, if the university guide is based on a 12-inch depth, it might be useful to collect two samples, 0 to 3 inches deep and 3 to 12 inches deep. Splitting the samples by depth allows you to compare soil test values for the 0- to 12-inch depth (weighted average of 0- to 3- and 4- to 12-inch depths) with the fertilizer guide, while also evaluating changes in surface soil test values (0 to 3 inches) over time. Table 3 shows how to calculate a weighted average.

How many soil cores should you collect for a composite sample?

Increasing the number of soil cores (subsamples) taken in a sampling area generally increases the accuracy of the data. Fewer soil cores are needed to represent a smaller sampling area (Table 4). Mix soil cores thoroughly and submit a

Table 3.—Calculating a weighted average.

How measured	Sample depth (inches)	Soil core length (inches)	Soil test value (ppm)
Sampled	0–3	3	40
Sampled	4–12	9	20
Calculated*	0–12	12	25

*Weighted average of 0- to 3- and 4- to 12-inch depths is derived by:
[(core length x soil test value) + (core length x soil test value)] ÷ total sample depth

Example: [(3 x 40) + (9 x 20)] ÷ 12 = 25

Table 4.—Minimum number of cores per sample and size of sampling areas.

	Whole field	Entire management unit	Reference sampling area within management unit
Minimum cores/sample	20	10	5–8
Minimum acres/site	100% of field	varies	1% or less of management unit

composite sample to the laboratory. Check with the laboratory to determine the amount of soil needed for the desired analyses.

Should you sample in a zigzag pattern or use a systematic sampling method within the sampling area?

For some crops, a zigzag pattern or other haphazard approach to collecting soil cores is appropriate. Systematic sampling perpendicular to a furrow-irrigated bed, fertilizer band, or perennial crop row sometimes is used to reduce variability in test results. If you choose a systematic sampling method, you must use it consistently in order to compare soil test values over time.

Sampling checklist

Consistent sampling techniques are essential. Make sure each of the following aspects (each was discussed above) will be handled before going to the field to take soil samples:

- Nutrients to be monitored
- Size and location of management units or reference sampling areas
- Sampling depth(s)
- Number of cores per composite sample
- Systematic sampling instructions (if applicable)

See "For more information" for publications describing routine soil sampling collection and handling techniques.

Example 1: Monitoring nitrogen in a silage corn field

Two years ago a grower purchased a 75-acre field. The new owner has no soil test data and little information on how the field was managed. He plans to conventionally till the field and plant it to silage corn and is concerned about how best to manage nitrogen fertilization. He uses best management practices to ensure timely and even distribution of irrigation water via overhead sprinklers.

The grower has a 20-year old aerial photo of the field and the soil survey report for the area. The photo shows that there was a corral in a part of the field. The grower decides that the former corral area will need to be a separate management unit (Management Unit 1), and the rest of the field will be the second management unit (Management Unit 2).

Developing a monitoring plan

Nutrient monitoring objectives

The grower wants to determine an appropriate nitrogen application rate for silage corn in this field. From a longer term perspective, by creating management units, he will be able to more closely meet the nutritional needs of the crops and, ideally, to reduce his fertilizer expenses and possible nitrate loss from the field.

Because part of the field has been a corral, the grower suspects this area may have a higher nutrient-supplying capacity than the rest of the field. The grower does not own livestock and will not be applying manure to the field.

Table 5.—PSNT and at-harvest stalk nitrate-nitrogen for Example 1.

	Nitrate-nitrogen (mg/kg or ppm)	
	Management Unit 1 (old corral site)	Management Unit 2 (rest of field)
Soil test (PSNT) at six-leaf growth stage	30	10
Corn stalk at harvest	4,500	5,500

Sampling approach

The grower wants to keep his sampling plan fairly simple by using reference sampling areas in the two management units. The reference sampling areas are located on the same side of the field and are fairly close to the road for easy access. Should plant tissue testing become necessary, those samples also will be taken from the reference sampling areas.

The grower has a GPS unit and uses it to record the location of the four corners of the reference sampling areas in the two management units. He collects 10 cores (5 cores is the minimum per unit) in each reference sampling area to create a representative sample.

Both soil and plant tissue testing will be used to monitor crop N status. Soil samples (0- to 12-inch depth) will be collected at the six-leaf growth stage. Plant tissue (corn stalks) will be collected at harvest. A university nutrient management guide, *The Presidedress Soil Nitrate Test (PSNT) for Western Oregon and Western Washington,* will be used to determine methods used in soil and plant tissue sampling. The guide also will be used to interpret soil test and plant tissue test results.

Results

Table 5 shows the results of soil and tissue testing for both management units.

The presidedress soil nitrate test value for Management Unit 1 (previous corral site) was above the 25 ppm nitrate-N sufficiency level given in the nutrient management guide. Thus, fertilizer N was not applied to this unit. Nitrogen was applied at sidedress time to Management Unit 2 at a rate of 100 lb N per acre as recommended in the guide.

The at-harvest stalk nitrate-N concentration in corn from Management Unit 1 was in the range required for optimum yield (above 3,500 ppm) given in the nutrient management guide. This result confirmed the decision not to sidedress N fertilizer in that management unit. Corn in Management Unit 2 had an at-harvest stalk nitrate value of 5,500 ppm, indicating that sufficient N was present for maximum yield. By using the management unit approach, yields were maintained and N fertilizer use was reduced.

Example 2: Monitoring soil phosphorus over a 6-year period

A grower has a 105-acre field that is irrigated with overhead sprinklers mounted on a wheel line. He wants to utilize composted manure from a drylot dairy and commercial fertilizers to supply nutrients for potatoes, a spring small grain crop, and a winter small grain crop grown in a 3-year rotation.

The grower worked with a consulting soil scientist to define management units for this field. The field was leveled many

Table 6.—Nutrient management strategies for Example 2.

Management unit	Initial soil test P	Strategy
1	15	Apply compost every year.
2	21	Apply compost every third year.
3	29	No compost applied.

years ago when it was furrow irrigated. Bare-soil aerial photographs were used to delineate management units defined by the amount of exposed subsoil. Soil color was directly related to topsoil depth, soil organic matter content, and soil test values. The management unit with the lightest color on the aerial photo, Management Unit 1, had the lowest organic matter content and the lowest soil test P value (15 ppm bicarbonate extractable P). Management Unit 3 had the highest organic matter content and the highest soil test P (29 ppm). Management Unit 2 had intermediate organic matter and intermediate soil test P (21 ppm).

Developing a monitoring plan

Nutrient monitoring objectives

The goal of the soil testing program is to efficiently use a combination of composted manure and fertilizer P to satisfy crop needs. Composted manure will be applied each year to Management Unit 1 (lowest soil test P) and every third year to Management Unit 2 (intermediate soil test P). Management Unit 3 will not receive composted manure application because it has higher soil test P values. (See Table 6.)

The phosphorus fertilizer rate for each crop will be determined using university nutrient management guides in conjunction with P soil test values for Management Unit 2 (intermediate soil test P) (Table 6). Phosphorus fertilizer (if needed for a particular crop) will be placed near the row at a single rate across the entire field. The grower does not have equipment capable of delivering a variable rate fertilizer application.

Sampling approach

Annual sampling will be used to track changes in soil test P over time. Because composted manure distribution across the field is not always uniform, the grower chooses a random sampling scheme, collecting soil cores in a zigzag pattern through each management unit. He records each management unit boundary and soil core collection location with a GPS unit to minimize year-to-year variation.

Management units will be sampled every year in the late winter or early spring. Samples will be taken at the 0- to 12-inch depth, as this is the depth recommended in university fertilizer guides for this region. From each management unit, 10 cores will be taken and composited into a single sample.

Results

Figure 2 (page 13) shows that soil test P values remained relatively constant in each management unit in the field over a 6-year period. All crops received adequate P for maximum yield.

The management unit approach allowed the grower to continue composted manure application to the portion of the field where additional P has agronomic benefit (Management Unit 1), while avoiding excess P buildup in the portion of the field

with higher soil test P values (Management Unit 3). Fertilizer costs were reduced because a portion of crop P needs was supplied by composted manure.

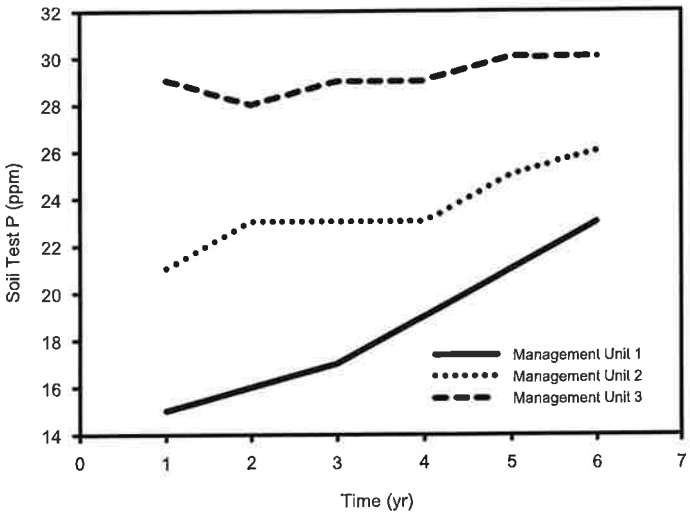

Figure 2.—Soil test P values for three management units in Example 2.

For more information

Franzen, D.W. and L.J. Cihacek. Soil Sampling as a Basis for Fertilizer Application, SF-990 (North Dakota State University, revised 1998).

Mahler, R.L. and T.A. Tindall. Soil Sampling, Bulletin 740 (University of Idaho, revised 1994).

Marx, E.S., N.W. Christensen, J. Hart, M. Gangwer, C.G. Cogger, and A.I. Bary. The Pre-sidedress Soil Nitrate Test (PSNT) for Western Oregon and Western Washington, EM 8650 (Oregon State University, reprinted 1997).

Marx, E.S., J. Hart, and R.G. Stevens. Soil Test Interpretation Guide, EC 1478 (Oregon State University, reprinted 1999).

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Russell Yost, University of Hawaii, Honolulu, HI

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NUTRIENT MANAGEMENT
FOR DAIRY PRODUCTION

The pre-sidedress soil nitrate test (PSNT)

for Western Oregon and Western Washington

E.S. Marx, N.W. Christensen, J. Hart, M. Gangwer, C.G. Cogger, and A.I. Bary

What is the Pre-sidedress Soil Nitrate Test (PSNT)?

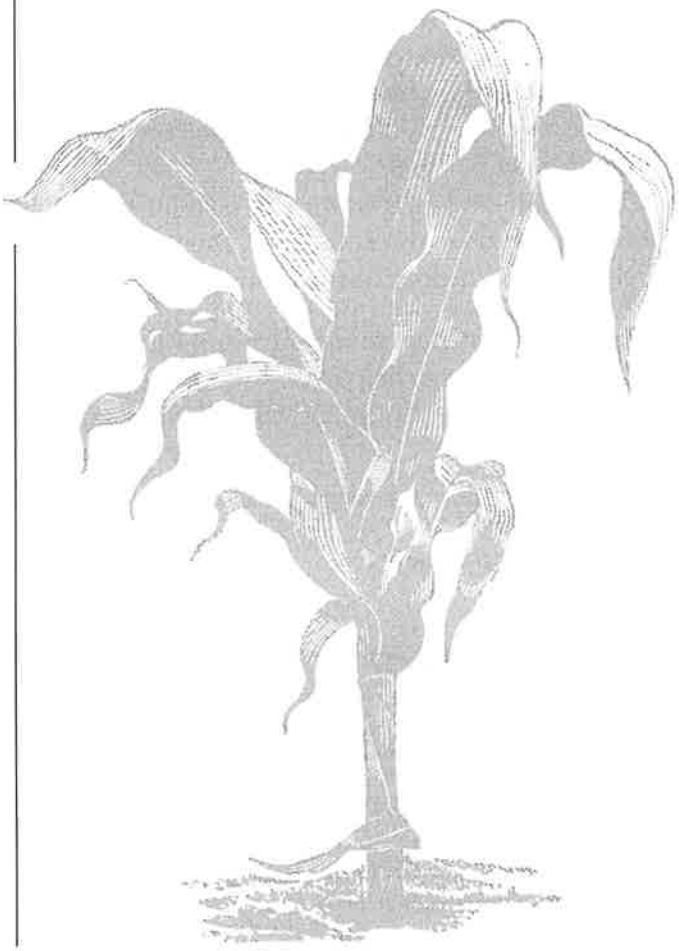
The Pre-sidedress Soil Nitrate Test (PSNT) evaluates nitrogen fertilizer needs for field corn. The PSNT can help ensure maximum yields without excessive nitrogen fertilizer applications. The benefits are reduced fertilizer purchases and reduced risk of environmental contamination.

Who can benefit from the PSNT?

Anyone producing corn for feed can potentially benefit from the PSNT. Growers who apply manure to their fields are especially likely to benefit. The organic matter in manure contributes nitrogen that is not well accounted for by other soil test methods.

Why does the PSNT tell more about nitrogen availability than early spring soil tests?

Soil tests performed in early spring do not tell how much nitrogen might be available later in the growing season. Most soil nitrogen is held in organic matter and is unavailable to growing plants. As the soil warms up, increased biological activity converts organic nitrogen into plant-available inorganic forms (Figure 1). An early spring soil test does not take this nitrogen into account. Thus, if you base fertilization on an early spring test, you might apply too much fertilizer.



E.S. Marx, former research assistant in soil science; Neil W. Christensen, professor of crop and soil science; John Hart, Extension soil science specialist; Mike Gangwer, Extension agent, Marion County; Oregon State University; C.G. Cogger, Extension soil scientist; and A.I. Bary, scientific assistant; Washington State University.

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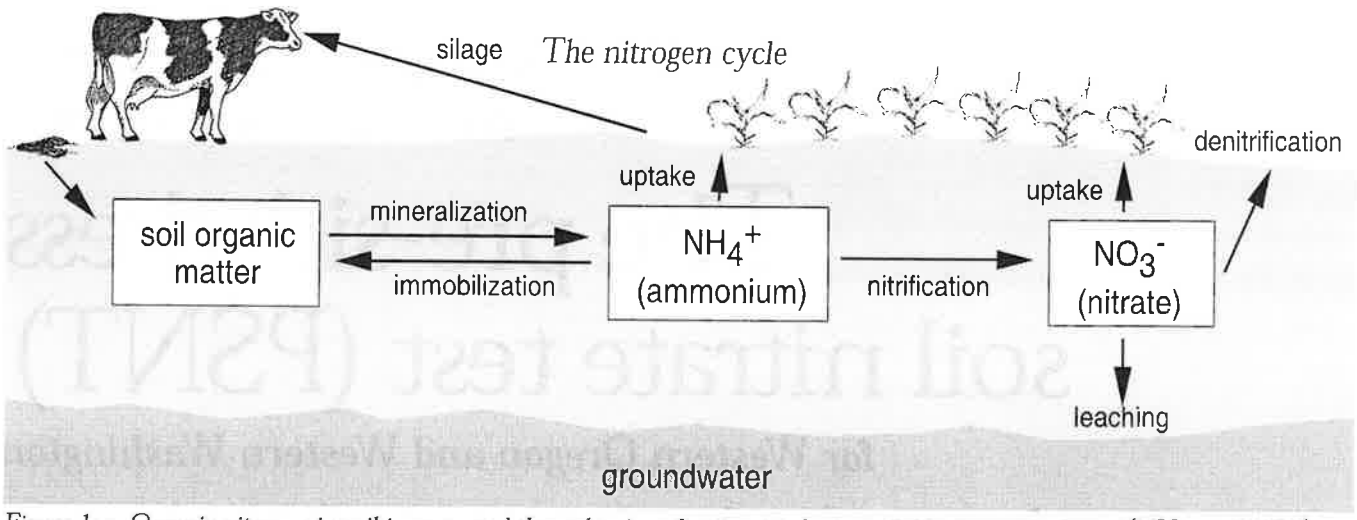


Figure 1.—Organic nitrogen in soil is converted through mineralization to plant-available inorganic forms (NH_4^+ and NO_3^-), which are taken up by growing plants.

The PSNT measures soil nitrate (NO_3^--N) during the growing season, after some nitrogen has become plant-available and just prior to the crop's period of greatest need.

How much N should I apply before planting?

If needed, apply no more than 40 lb N/acre as a starter in spring. Most fields with a history of manure applications require no starter N fertilizer. If starter N is needed, it can be supplied by manure or commercial fertilizers.

Delay as much N fertilization as possible until midseason. If the midseason PSNT shows low N levels, make a sidedress fertilizer application.

When is the best time to measure soil nitrate?

Corn plants begin their greatest uptake of nitrogen around the 5-leaf stage, or when the plants are about 12 inches tall at the center of the whorl. The best time to evaluate soil nitrogen is just prior to this period of rapid uptake (Figure 2).

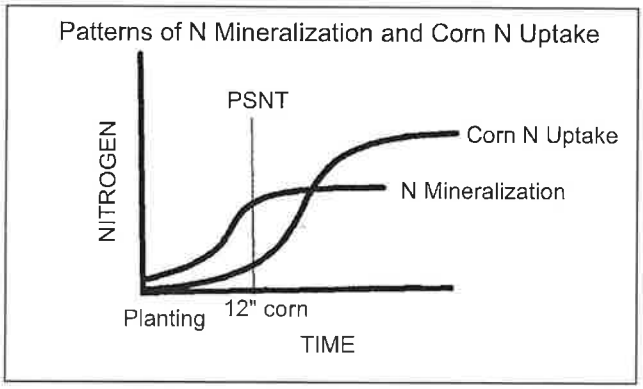


Figure 2.—Perform the PSNT when corn is 12 inches tall (before rapid nitrogen uptake by corn and after some nitrogen mineralization has occurred).

How much N is enough?

A PSNT value of 25 ppm or greater is sufficient for maximum silage corn yields. If the PSNT value is below 25 ppm, apply nitrogen at the rates shown in Table 1.

Nitrogen can be supplied by manure or commercial fertilizer. Most dairies produce enough manure to supply needed N, making fertilizer purchases unnecessary. See EM 8585, *Manure Application Rates for Forage Production*, for more information.

What if I apply more N than the crop needs?

Excess nitrogen will not be used by the crop and will remain in the soil after harvest. During winter, rain may wash nitrate from the soil into surface and ground waters. This poses a threat to human and environmental health and wastes fertilizer dollars.

Table 1.—Suggested N fertilization rates based on PSNT values.

PSNT value (ppm NO_3^--N)	Estimated N to apply (lb N/acre)
0–10	100–175
10–20	50–100
20–25	0–50
over 25	0

Soil sampling and handling procedures

1 **When to sample**. Sample soil when the corn has 5 *collared leaves*, or at least a week before planned sidedressing. This usually coincides with a plant height of about *12 inches* at the center of the whorl.

2 **Where to sample**. Sample between rows, away from fertilizer bands. Avoid irregularities in the field, such as low areas or places where manure has accumulated.

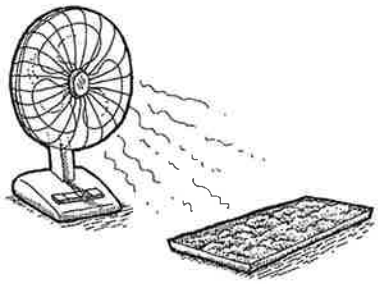
Collect a composite sample of *15–20 cores*. The more cores you collect, the better your chance of getting an accurate measurement.

3 **How to sample**. Sample soil to a depth of *12 inches*.

4 **Preparing the sample**. Mix the sample thoroughly in a clean container. Save a subsample sufficient to fill a soil sample bag.

Dry this sample immediately. Drying is important to stop biological activity, which could alter soil nitrate content. Dry the sample by spreading it on a clean piece of paper in a warm, well-ventilated area. A fan can increase air flow. Do not use a microwave oven to dry the sample.

If you cannot dry the sample immediately, refrigerate it in a cooler and dry it later the same day. If you cannot dry or deliver the sample to a lab the day it is collected, freeze it.



5 **Soil analysis**. Send the sample to a soil testing lab to be analyzed for nitrate-nitrogen (NO_3-N). See FG 74, *A List of Analytical Laboratories Serving Oregon*, for a list of labs.

6 **Interpreting results**. If soil nitrate levels are *above 25 ppm*, no additional nitrogen fertilizer is needed. If soil nitrate levels are *below 25 ppm*, apply fertilizer at the rates shown in Table 1.

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Hart, J. *A List of Analytical Laboratories Serving Oregon*, FG 74 (Oregon State University, Corvallis, revised 1996). No charge

Hart, J., M. Gangwer, M. Graham, and E.S. Marx. *Manure Application Rates for Forage Production*, EM 8585 (Oregon State University, Corvallis, 1996). $1.00

Hart, J., E.S. Marx, and M. Gangwer. *Dairy Manure as a Fertilizer Source*, EM 8586 (Oregon State University, Corvallis, reprinted 1996). $1.00

Other publications

Magdoff, F. Understanding the Magdoff Pre-sidedress Nitrate Test for Corn. Journal of Production Agriculture 4 (1991): 297-305.

Marx, E.S. *Evaluation of Soil and Plant Analyses as Components of a Nitrogen Monitoring Program for Silage Corn* (Master's thesis, Oregon State University, 1995).

This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.

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Post-harvest Soil Nitrate Testing

for Manured Cropping Systems West of the Cascades

D.M. Sullivan and C.G. Cogger

Contents

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What's in this publication?

This publication describes the use of post-harvest soil nitrate testing as a tool for assessment of nitrogen (N) management in manured cropping systems west of the Cascade Mountains in Oregon, Washington, and south coastal British Columbia.

The first section of this publication gives general information on the test and is designed for use by growers and dairy operators. This section gives a brief introduction to soil sampling, but does not provide all of the technical details. The focus is on how to use the post-harvest test to improve nutrient management. This section describes:

- What the post-harvest test measures
- How to collect soil samples
- Units used in soil nitrate testing
- How to interpret soil nitrate test results for grass and silage corn crops

In addition, background information explains the rationale for the test:

- How to use the post-harvest test as a management tool (page 3)
- Crop and soil response to excess plant-available N (page 4)

Dan M. Sullivan, Extension soil scientist, Oregon State University, and Craig G. Cogger, Extension soil scientist, Washington State University.

The second section of this publication is designed primarily for use by conservation planners and other agricultural professionals working with farmers to implement nutrient management plans. This section is also designed for dairy operators who do their own soil sampling. This section includes detailed suggestions for the following:

- Collecting, preserving, and analyzing the soil sample
- Developing a long-term soil sampling plan

The post-harvest test and how to use it

What the post-harvest test measures

The post-harvest soil nitrate test measures the quantity of plant-available nitrogen present in the nitrate form in the surface foot of soil in the late summer or early fall. The test measures nitrate-N not utilized by the recently harvested crop. Because crops differ in their ability to remove nitrate-N from the soil, test interpretation is crop-specific.

The test looks backward in time. It evaluates the balance between N supply and crop uptake for the crops produced during the summer. Nitrate-N accumulates in the soil when more plant-available N is supplied than can be utilized by the summer crop (see "Crop and soil response to excess plant-available N," page 4).

Use the post-harvest test to:

- Get a general idea of balance between N supply from manure and other sources and crop N demand
- Identify imbalances in N supply among fields on a farm
- Identify fields that may respond to changes in timing or amount of manure application or other agronomic practices

Soil sampling protocols

Sampling depth

Sample the 0- to 12-inch depth for the post-harvest test. This shallow sampling depth is a good predictor of nitrate in the rest of the soil profile when (1) in-season irrigation is not excessive, and (2) samples are taken prior to heavy rains in the fall.

Composite soil sample

Collect a composite soil sample consisting of a mixture of 15 to 30 soil cores from each field or management unit. See "Collecting, preserving, and analyzing the soil sample" (page 9) for detailed sampling instructions and suggestions for special situations.

What fields to sample

In general, it is not necessary to sample every field on a farm every year. Consult with your farm advisor to determine any regulatory requirements for sampling frequency. We recommend that you sample selected fields that represent typical manure and crop management practices each year to track long-term trends in post-harvest soil nitrate values. See "Developing a sampling plan" (page 11) for more information.

When to sample

In general, samples for the post-harvest test should be collected as soon as possible after a crop harvest. Avoid sampling a field that has had manure application within the past 30 days.

Samples must be taken before heavy fall rains move nitrate below the 12-inch depth. Because the timing of fall rainfall is unpredictable, the best strategy is to sample fields before October 1 whenever possible.

Collect samples from medium- to fine-textured soils (loams, clay loams, and clays) prior to 5 inches of cumulative fall rainfall. Sandy soils (sand, loamy sand, or sandy loam soil texture) have lower water-holding capacities and should be sampled prior to

continues on page 5

How to use the post-harvest test as a management tool

Sampling depth and timing are critical. Interpretation tables for this test apply only to samples taken to a 12-inch depth. Surface soil (0 to 12 inches) typically contains the highest nitrate-N levels and requires the least time and effort for sample collection. Samples must be taken before heavy fall rains move nitrate below the 12-inch depth. The target sampling period generally is August 15 to October 15.

To get the most value from this test, it is important to understand:

- How the test fits into an overall nutrient management program
- Limitations to interpretation of test results
- How *not* to use the test

Using the test as part of a nutrient management program

The post-harvest test is but one measure of success in nutrient management. Post-harvest nitrate test data should be assessed in the context of the current N management plan and records of manure application. Successful N management involves a number of components, including:

- Assessing crop N needs
- Planning manure application to meet crop N needs
- Applying manure according to the plan
- Recording manure application amount and estimated plant-available N amount
- Measuring crop yield and N content
- Monitoring success of the plan

All components of the nutrient management system should be evaluated together.

Limitations to test results

Interpretive values for post-harvest soil nitrate are:

- Calibrated only for high-rainfall portions of the Pacific Northwest (west of the Cascades). Extrapolation to other environments is not recommended.
- Provided only for corn silage and grass hay/silage crops. Field research has been used as the basis for interpretive levels for these crops. Applicable research data are not available for other crops to determine post-harvest nitrate-N levels associated with good crop and nutrient management practices. However, the test may be used for relative comparisons among fields planted to another crop (e.g., comparisons among grass pasture fields).
- Based on the assumption that summer irrigation is less than, or close to, evapotranspiration to ensure that significant nitrate leaching does not occur before the fall test.
- Designed for fields with a history of applied manure (more than 3 consecutive years of regular manure application). Lower post-harvest soil nitrate test values are attainable where only fertilizer N is used, or where manure is applied infrequently.
- Based on good management of the crop and normal yields. Crop moisture stress, insect damage, or plant disease will reduce crop yield and crop uptake of nitrogen, thus increasing post-harvest soil nitrate test levels.

How *not* to use the post-harvest test

The test will *not*:

- Detect a shortage of plant-available nitrogen for crop production. Continual mineralization of nitrogen (conversion of organic N forms to plant-available N forms in the soil) can provide enough plant-available nitrogen for a crop without accumulation of nitrate-N in soil.
- Determine the source(s) of excess plant-available N. Sources of N may include manure slurry, lagoon water, fertilizer, soil organic matter, or previous crop residues.
- Predict crop response to fall manure or N fertilizer applications. The test does not predict the amount of plant-available N that will be mineralized from soil organic matter or crop residues in the fall.

Crop and soil response to excess plant-available N

Crop response to applied N. Crop N uptake is controlled by the environment, crop N uptake potential, and management. Crops respond to plant-available nitrogen supply (ammonium + nitrate-N) by the law of diminishing returns (Figure 1). Without added N, some crop yield is produced from N supplied by soil organic matter, residual plant-available N, and other non-fertilizer sources (e.g., mineralization of crop residues). Additional N supplied from manure or fertilizer increases crop yield until site yield potential is reached.

The application rate of manure or N fertilizer needed to reach near-maximum yield is termed the *agronomic rate*. Rather than a single agronomic rate, the crop response to N is best described as an agronomic rate range (Figure 1). The agronomic rate range concept allows for variability in crop performance among years and for crop uptake of N beyond the yield maximum (increased protein).

Post-harvest soil nitrate test measures nitrate-N not used by the crop. At excessive plant-available N supply levels, crop yield and crop N uptake do not respond to further N additions. The extra soil N not used by the crop accumulates as nitrate-N.

Elevated post-harvest soil nitrate-N concentrations are an indicator of one or more of the following: (1) excess plant-available N, (2) N supplied too late in the season for crop utilization, or (3) poor crop growing conditions due to insect infestation, moisture/heat stress, plant disease, or other cultural problems. If crop yields are acceptable and crop protein is at typical levels, then the most likely explanation is that plant-available N was supplied in excess of crop needs.

Because grass is more efficient than corn at N uptake, target post-harvest soil nitrate levels given in this publication are lower for grass than for corn. There are two key reasons that grass is more efficient than corn in N removal.

- Grass has a greater capacity to take up N supplied in excess of that needed for maximum yield. After enough N has been supplied for maximum yield, grass protein content increases in response to increased N supply. With grass, soil nitrate increases only when the available N supply exceeds that required to produce near-maximum protein. Corn does not take up additional N after the maximum yield is reached. Corn silage protein does not increase much in response to excess N supply.
- Grass utilizes N mineralized late in the growing season more efficiently. Grass managed for silage or hay continues to take up N until harvest. Corn grown for silage completes its N uptake approximately 4 weeks before harvest. Some of the soil nitrate measured after corn harvest is produced by mineralization of soil organic N to available forms during the final weeks of the growing season.

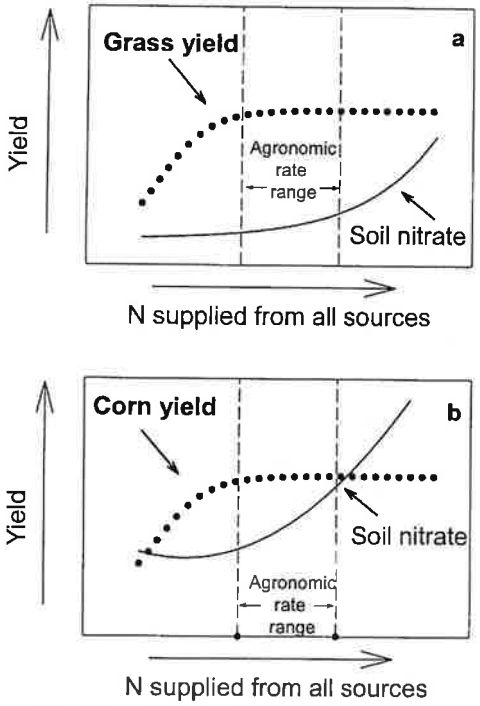

Figure 1.—Crop yield and soil nitrate response to increased N supply. Agronomic rate range = range of N supplied from all sources that results in near-maximum crop yield with acceptable post-harvest nitrate accumulation. Above the agronomic rate range, excess N accumulates as nitrate in soil. More nitrate accumulates in the agronomic rate range with corn (b) than with grass (a).

Table 1.—Average calendar date when cumulative rainfall (after September 1) reaches 5 inches west of the Cascades.[a]

Cumulative rainfall after Sept. 1	Calendar date to reach specified cumulative rainfall							
	Medford (OR)	Salem (OR)	Tillamook (OR)	Coupeville (WA)	Centralia (WA)	Lynden (WA) Abbotsford (BC)	Agassiz (BC)	Comox (BC)
(inches)								
3	10 Nov	20 Oct	26 Sep	31 Oct	8 Oct	1 Oct	26 Sep	10 Oct
5	29 Nov	1 Nov	8 Oct	24 Nov	23 Oct	15 Oct	9 Oct	25 Oct
7	16 Dec	13 Nov	18 Oct	15 Dec	4 Nov	27 Oct	19 Oct	6 Nov

[a]Average daily precipitation data for many other locations is available at: Western Regional Climate Center (http://wrcc.dri.edu) or Environment Canada (http://www.msc-smc.ec.gc.ca/climate/climate_normals/index_e.cfm).

3 inches of cumulative fall rainfall. The starting date for calculating cumulative fall rainfall is September 1. Include inches of irrigation water applied after September 1 in your estimate of cumulative rainfall.

Table 1 shows the average calendar date when cumulative fall rainfall (after September 1) reaches 5 inches at a variety of locations. For most locations, sampling prior to October 15 is acceptable in an average year. In high rainfall areas (coastal areas and the Cascade foothills), plan to sample earlier. A late October sampling date usually is acceptable in lower rainfall areas of southern Oregon, the Puget Sound islands, Olympic Peninsula, or Vancouver Island.

Units used in soil nitrate testing

In this publication, interpretation of a post-harvest soil nitrate test (Tables 3 and 4) is based on units of parts per million (ppm). Some labs report soil test nitrate-N in units of lb/acre by assuming a standard value for soil bulk density. If the lab reports nitrate-N results in pounds per acre, ask them to provide a conversion factor to express data in units of ppm. The conversion factor assumed by laboratories usually is between 3 and 4, because 1 acre-foot of dry soil usually weighs about 3.5 million pounds (3.5 lb per acre-foot = 1 ppm).

Table 2.—Units used to report soil nitrate analyses.

Name	Interpretation	Equivalent units
nitrate-N or NO_3-N	N present in the nitrate form, soil dry weight basis	mg/kg or ppm (dry weight basis)

Interpreting soil nitrate test results

Data quality and variability

The first step in evaluating your soil nitrate data is to verify data quality. Determine whether the sample collection method, timing of sample collection, sample preservation, and laboratory analysis methods are acceptable. Reject data that did not result from reasonable protocols. For example, Tables 3 and 4 should not be used for soil samples collected in November after heavy fall rains.

Make sure that you understand the units used to report test results. See Table 2 for an explanation of units found in soil test reports.

Response of post-harvest soil test N to changes in management

Success in N management is indicated by long-term trends in post-harvest soil nitrate (at least 3 to 5 years). **Because of the large pool of readily mineralizable N in manured soils, fall soil nitrate values may not decline for 3 to 5 years in response to improved management.** For multiyear comparisons, sampling methods and timing must be consistent.

Some portions of a crop rotation will have higher fall nitrate values because of rapid N mineralization stimulated by tillage or incorporation of crop residues. For example, soil nitrate concentrations typically are high, regardless of overall N management, after a perennial grass sod is plowed down and reseeded.

Reductions in fall soil N are most likely to be measured when (1) commercial N fertilizer amounts are reduced or eliminated, (2) cropping systems that maximize N removal in late summer and fall (August to October) are used, and (3) manure or N application is eliminated after August 1. It is more difficult to attain post-harvest soil nitrate-N values of less than 20 ppm for corn than for grass (see "Crop and soil response to excess plant-available N," page 4).

Interpretation for individual fields

Interpretations of soil test nitrate-N should be made first at the field level. You may be able to discover a probable cause for differences in test values among fields. Questions to ask include:

- Are relationships present between known management factors (e.g., manure application rate or timing, crop yield and quality, irrigation frequency, distance to the barn) and soil test values?
- Is a large amount of variation present between fields? Is there a logical explanation for unusual values?
- Are values for grass and corn fields similar?

Annual averages across grass and corn crops

After looking at test values for individual fields, it may be useful to look at averages across all grass or corn fields. You may want to calculate averages only for fields under similar management.

Average nitrate-N test values are most useful for consideration of changes in whole farm nutrient management. Tables 3 and 4 present interpretive information separately for grass and corn fields.

If a few fields have unusual test values, you may be justified in excluding those fields from an average. Although you may want to exclude unusually high test values from the farm average, you definitely should evaluate those fields further to determine the probable cause of the high soil test values. The unusually high test values may reflect the need for management changes or may reflect a soil sampling or analytical error.

Using the interpretive tables (Tables 3 and 4)

Interpretations and management suggestions given in Tables 3 and 4 (pages 7–8) are general in nature and should serve as only one portion of a nutrient management plan evaluation. Some of the management suggestions can be implemented for individual fields, while others need to be implemented on a whole farm basis.

Remember not to focus solely on post-harvest nitrate-N in evaluating N management. Include other important aspects of N management in your evaluation, such as success in following a plan for manure application, calibration of manure application equipment, maintaining good manure application records, and effective irrigation management.

Table 3.—Silage corn. Suggested interpretation for post-harvest soil nitrate-N (0- to 12-inch depth).[a]

If post-harvest nitrate-N is less than 20 ppm (less than approximately 70 lb N per acre)

- Continue present N management.

If post-harvest nitrate-N is 20 to 45 ppm (approximately 70 to 160 lb N per acre)

- Reduce or eliminate sidedress N fertilizer application. Use the pre-sidedress nitrate test (PSNT). Apply sidedress N only when PSNT indicates a need.
- Reduce lagoon water application after August 1.
- Keep records to document crop yield, dry matter, and crop N removal. Total applied manure-N + fertilizer-N should be less than 125 percent of documented crop N removal.
- Reduce manure application on fields where corn follows grass sod plow-down.
- Plan to reduce manure-N application by 10 to 25 percent.
- Improve whole farm N balance.

If post-harvest nitrate-N is greater than 45 ppm (greater than approximately 160 lb N per acre)

- Apply only starter N (20 to 40 lb N/acre at planting).
- Plan not to sidedress N fertilizer in June. Apply sidedress N only when PSNT indicates a need.
- Eliminate lagoon water application after August 1.
- Keep records to document crop yield, dry matter, and crop N removal. Apply manure N at a rate less than or equal to crop N removal (approximately 200 lb total N per acre).
- Eliminate manure application on a few fields or a few strips within a field next year to determine the contribution of mineralized N vs. current-season application of manure.
- Plan to reduce manure-N application by 25 to 40 percent.
- Consult experts to improve whole farm nutrient balance.

[a]The post-harvest test values listed above are for the *end* of a growing season. Management changes (if needed) should be implemented in future years. Interpretive values assume near-optimum crop yields. If yield is below average, improve agronomic practices to increase crop yield and crop N uptake.

Table 4.—Grass for hay or silage. Suggested interpretation for post-harvest soil nitrate-N (0- to 12-inch depth).[a]

If post-harvest nitrate-N is less than 15 ppm (less than approximately 55 lb N per acre)

- Continue present N management.

If post-harvest nitrate-N is 15 to 30 ppm (approximately 55 to 105 lb N/acre)

- Apply manure earlier in the growing season.
- Keep records to document crop yield, dry matter, and crop N removal. Total applied manure-N + fertilizer-N should be less than 125 percent of documented crop N removal.
- Check protein levels in forage. Grass crude protein greater than 21 percent is associated with increased potential for nitrate toxicity to cows.
- Plan to reduce manure-N application by 10 to 25 percent.
- Improve whole farm nutrient balance.

If post-harvest nitrate-N is greater than 30 ppm N (greater than approximately 105 lb N/acre)

- Apply manure earlier in the growing season. Reduce manure application after August 1.
- Keep records to document crop yield, dry matter, and crop N removal. Total manure-N + fertilizer-N should be less than or equal to crop N removal. Even if calculated crop removal exceeds 400 lb N per acre, apply manure-N + fertilizer-N not to exceed 400 lb N per acre per year.
- Consider reseeding or interseeding if grass yield is limited by poor stand or undesirable species.
- Check protein levels in forage. Grass crude protein greater than 21 percent is associated with increased potential for nitrate toxicity to cows.
- Plan to reduce manure-N application by 25 to 40 percent.
- Consult experts to improve whole farm nutrient balance and reduce danger of nitrate toxicity to cows.

[a] The post-harvest test values listed above are for the *end* of a growing season. Management changes (if needed) should be implemented in future years. Interpretive values assume near-optimum crop yields. If yield is below average, improve agronomic practices to increase crop yield and crop N uptake.

Detailed suggestions for soil sampling and planning

Collecting, preserving, and analyzing the soil sample

Tools for field sampling

Collect a sample that is representative of the entire sampling depth. For example, a representative sample for a 0- to 12-inch depth has the same amount of soil from the soil surface (0 to 6 inches) and from the bottom of the sampling depth (6 to 12 inches).

Always use a tool specifically designed for soil sampling. Don't use a shovel, because the samples won't be uniform with depth. Tools for soil sampling often are called soil probes or augers. There are several kinds available.

Push probes are tubes that you push into the soil. They have a T-shaped handle attached to a cylindrical tube (about 1 inch diameter) with a beveled tip. The tube collects a cylinder, or "core," of soil. Push probes work well in soft, uncompacted soils.

Hammer probes are designed for hard or compacted soils. They have a sliding weight (hammer) instead of a T-handle to drive the probe into soil.

Soil test consultants often use hydraulic probes mounted on a tractor or pickup to sample soils. These reduce the time and effort of sampling in hard soils. Gravelly and rocky soils are difficult to sample. A hydraulic probe with a rotating auger can sample some gravelly soils.

A mud auger or bucket auger is the best tool for hand-sampling at sites that are difficult to sample with push probes. Use an auger for compacted, muddy, rocky, or dry soils. Augers can be purchased from several manufacturers. A 2- to 4-inch diameter mud auger (open-sided) works best for most situations because it is easy to remove the sample from the bucket. Use a larger diameter auger for soils with large rocks. Augers sample a 4- to 6-inch depth. You will need to take several bites from the same hole to sample to 12-inch depth. You will collect a larger sample volume, about 5 to 10 times that collected with a push tube. Because of the extra effort required for auger sampling, use this method only if other sampling methods are difficult or impossible.

Field sampling protocol

Plan ahead. Use field maps and soil maps to divide the farm into different management units. A management unit is usually a field, but you may want to subdivide a large field if sections can be managed separately for nutrient application. The simplest approach is to collect a composite sample from the entire management unit. You may choose to restrict sampling to the dominant soil type if the management unit has soils that differ markedly in visual appearance (soil color, texture, organic matter).

Alternatively, you can restrict your sampling to a representative area (usually about an acre in size) within the management unit. Choosing a representative area within the field where manure application rate, timing, and uniformity are well documented is essential. If you use the "representative area" sampling approach, record the sampling location using a GPS receiver or record the distance from a fixed location (e.g., fenceline).

Avoid large buffer zones that are sometimes present adjacent to water bodies or roads, especially with big gun manure applicators. Avoid small atypical areas such as:

- Swales
- Very rocky or shallow soil (less than 12 inches deep)
- Site of an old manure pile or a feeding, watering, or resting area for livestock
- Abandoned field roads
- Field edges

Collect 15 to 30 soil cores from each management unit or representative sampling area with a push probe or similar tool. If you use an auger, 10 holes per management unit or zone is sufficient.

Choose sampling locations in a zigzag pattern across the field. Your general route of travel should be across rows, rather than down one row in the field. Make sure you sample within the part of the field where manure is routinely applied. For grazed pastures, choose sampling locations that have average crop growth and productive forage species.

Scrape away loose crop residues or manure present on the soil surface. Sample only the soil. Including the accumulated organic debris from the soil surface in the soil sample will increase variability in test results.

Once you are satisfied with a sampling strategy, repeat the same procedure each year. This will increase the validity of year-to-year comparisons of results.

Obtaining a representative sample from fields where manure has been injected into soil or placed in bands on the soil surface is difficult. The depth of manure injection, the width of injection zone, and the spacing between bands depend on equipment, soil, and the applicator. Some injection equipment can place manure below the 12-inch sampling depth used for the post-harvest nitrate test. Manure may be injected or banded more than one time per year, with several orientations in a field (e.g., north–south or east–west). Because of the added variability associated with manure injection or banding, plan to collect a larger number of soil cores to obtain a representative composite sample.

Sample handling

Mixing. If it is not too hard to break up the soil cores, break them, mix them all together, and homogenize thoroughly. Take a 1-cup subsample for shipment to the lab. If the soil cores are too hard to break apart, send the entire sample to the lab, where they can pass the sample through a mechanical grinder. Check with the lab to make sure they will grind and mix the *entire* sample before subsampling.

Preservation. Soils kept moist and warm continue to accumulate nitrate via biological activity after sampling. The simplest way to limit biological activity is to cool the soil after collection. Put the samples in plastic bags and place them in a cooler on ice while still in the field. Refrigerate them when you return from the field. Freeze the samples if they will be held longer than 48 hours before analysis.

Shipment. Keep the samples refrigerated or frozen until you deliver them to the lab. Contact the lab before you sample, so they will be prepared to receive the samples. Use a shipping method that will get the samples to the lab within 48 hours. You may want to freeze the samples before shipping to make sure they remain cool in transit.

Working with an analytical laboratory

Choose a laboratory that has experience with agricultural samples. Ask if they participate in the North American Proficiency Testing Program or a similar quality assurance program for agricultural testing labs. Find out what extraction and analytical procedures they use. Procedures should be consistent with those recommended for the western states (Gavlak et al., 1994).

Labs may use one of several colorimetric (color-based) lab procedures or they may use an electrode method to measure nitrate. Sample comparisons have shown that the colorimetric procedures usually are more precise than the electrode method.

Some testing labs also have sampling and consulting services. This can be convenient for people who have little experience in sampling or need help with sampling.

Find out how the lab reports soil test data. Standard units for soil nitrate-N are parts per million (ppm, Table 2). If you aren't familiar with the lab, it's a good idea to obtain a copy of a sample laboratory report.

Because you will use sample results to compare post-harvest soil nitrate across years, laboratory consistency over time is a major issue. A standard reference sample (soil sample with known concentration of nitrate) can help you assess laboratory variability. Consider submitting a standard reference sample (approximately 50 to 100 g dry weight) with a nitrate-N concentration of 20 to 45 ppm with each batch of soil samples. Keep track of test results for the standard reference sample over time. If you note a major error in the nitrate concentration reported for the standard reference sample, then the test data is questionable.

Standard reference samples are available from the North American Proficiency Testing Program (see "For more information," page 15). Standard reference samples must be dried, ground, and thoroughly mixed.

We do not recommend that you split a field sample to check laboratory consistency. The one-time nature of such comparisons, the uncertainty of obtaining a homogeneous sample, and the uncertainty of sample preservation in-transit to the lab limit the interpretation of split-sample data.

Developing a sampling plan

Nutrient management plans can be voluntary, required by regulatory agencies, or a part of an agreement with a conservation planning agency (e.g., Natural Resources Conservation Service or conservation district). If your nutrient management plan is not voluntary, consult the agency that supervises your nutrient management plan to determine whether they have specific requirements for how often fields must/should be sampled. Suggestions given here for sampling frequency are general in nature and are not intended to serve as policy for any agency.

Representative fields for long-term monitoring

Representative fields are fields that you sample every year to track trends in sample values over time. Select fields that represent typical management practices. Criteria that can be used to choose representative fields include: (1) records or estimates of annual manure application rate, (2) number of years of continuous manure application, (3) soil test values for P and K. On dairies where P and K fertilizers are not routinely applied, soil test values above 75 ppm P (Bray P1 method) and 400 ppm K (ammonium acetate method) usually reflect substantial manure application in the past.

Sample the representative fields every year to assess trends over time. If you grow corn silage and perennial grass forage, plan to sample at least four grass fields and four corn fields each year. At a small dairy (fewer than four fields), sample all fields each year.

Other fields

Periodically, you will need to evaluate the fields not designated as "representative" fields. Consider sampling all fields every 3 years. Compare whole farm soil data to representative field data.

If you have only a few fields with elevated soil test N, then focus management on those fields. If all fields on the farm give similar test data, then focus your N management efforts at the whole farm level. If representative fields consistently have test values of less than 15 ppm (grass) or less than 20 ppm (corn) over a 3-year period, and all other fields sampled have similar test values, consider reducing the number of post-harvest soil nitrate tests.

Sampling priority

Prioritize fields for fall sampling ahead of time so that you get high-priority fields sampled at an appropriate time. Highest priority should be given to representative fields used to track long-term trends. Fields with high manure application rates or elevated soil test N the previous year should also have a high priority.

Corn fields can be sampled for soil nitrate in June (PSNT, pre-sidedress nitrate test) or in the fall (post-harvest test described in this publication). You will get the most management information by sampling your high-priority representative corn fields both in June (PSNT) and after harvest. You also may want to sample fields with PSNT values greater than 45 ppm nitrate-N again in the fall.

For other corn fields where only one soil test per year is planned, we recommend using the PSNT in preference to the post-harvest soil nitrate test. The PSNT is preferred because test results are applicable to in-season N management. Growers can save money and reduce post-harvest nitrate by omitting sidedress N fertilizer application on fields where sufficient soil nitrate-N is present in June.

Sampling corn fields at PSNT time also will reduce the number of post-harvest samples that need to be collected during the short interval between harvest and the end of the fall sampling window (approximately October 15). If you miss a planned fall sampling on a corn field, consider sampling next year using the PSNT.

Grass fields are best sampled in the fall, using the protocols described in this publication. Think carefully about the best way to achieve consistent timing of sample collection for your fields. The timing of manure application and the timing of grass harvest are key variables to consider.

Samples collected shortly after manure application are not a good indicator of the balance between N supply and crop N demand over the entire growing season. If manure is applied late in the year, postpone soil sampling until after a fall grass harvest. Wait at least 30 days after a late-season manure application before sampling. Sampling need *not* be postponed until after the last manure application or until after the last grass harvest in the fall.

Questions and answers

Why is it difficult to achieve post-harvest nitrate-N less than 15 to 20 ppm with organic sources such as manure?

First, the timing and rate of application for organic sources is less flexible than for fertilizer N. Second, environmental processes that control the quantity and timing of N availability from organic sources are difficult to manage. The biggest factors controlling N availability are soil temperature and moisture. The timing of crop N uptake usually does not match the timing of N supplied from manure and other organic sources. Soil temperature and moisture often support continued release of available N after crop N uptake is complete.

Is there a relationship between soil organic matter content and potential N mineralization?

Research west of the Cascades has demonstrated a lack of correlation between soil organic matter content and N mineralization potential for soils having 3 to 8 percent organic matter. The active fraction of soil organic matter that controls annual N mineralization rates is a small proportion of total organic matter (usually less than 10 percent of total). Recent site management affects soil N mineralization potential; it does not have much effect on soil organic matter content. Because most soil total N is contained in soil organic matter, soil total N is also an unreliable indicator of mineralization potential.

What other soil tests can be used to provide information to guide N management for corn?

Soil nitrate testing in spring and early summer can assist with N management for silage corn. Test soil ammonium + nitrate-N several weeks after a spring manure application to track early-season N availability. Test soil nitrate when corn is at the four- to six-leaf stage (pre-sidedress nitrate test, PSNT) to determine the need for sidedress N application to corn.

How much variability should I expect in post-harvest nitrate-N test values for the same grass field sampled between August 15 and October 15?

It all depends on weather, soil biology, and crop management. A good stand of actively growing grass can maintain nitrate-N concentrations of less than 15 ppm throughout the post-harvest sampling period. Where soil is dry in late summer, increased N availability may occur for 2 or 3 weeks following the first heavy rain. It may be useful to take several soil nitrate tests from the same field in the fall to document changes in nitrate concentration with time. Soil nitrate values given in the interpretive table in this publication are for typical precipitation and sampling date.

Ammonium-N is plant-available. Why doesn't the post-harvest test include ammonium-N analysis?

Post-harvest ammonium-N analyses cost money, and they do not yield reliable interpretive information. Ammonium-N does not accumulate in soils supplied with an excess of plant-available N. It is rapidly converted to nitrate. Soil samples taken at least 30 days after manure application usually have negligible ammonium-N concentrations unless soil has remained dry.

Drying of soils after sampling releases ammonium-N from microbial biomass. Most dried soils have 2 to 20 ppm ammonium-N that is caused by the soil drying process. Dry soil ammonium-N concentrations are poorly correlated with other indices of N availability in controlled experiments.

Should post-harvest nitrate tests be used for fields with organic soils?

Other methods should be used to assess the success of nutrient management plans on organic soils. Goals for post-harvest nitrate-N of less than 20 ppm are difficult if not impossible to attain on organic soils, which contain more than 20 percent organic matter. These soils formed as organic matter accumulated under natural poorly drained conditions. Soil organic matter decomposition and N mineralization processes are greatly accelerated under typical farming practices such as artificial drainage and tillage.

Should I measure or estimate soil bulk density to estimate post-harvest nitrate-N in units of pounds per acre?

The variation in bulk densities among soils typically is less than the variation associated with soil nitrate sampling and testing. Interpretive information in this publication is based on units of parts per million (ppm; mg per kg dry soil). You can approximate soil nitrate-N in the surface foot of soil by assuming typical bulk density (ppm x 3.5 = lb/acre). This conversion factor is based on the weight of 1 acre-foot of soil at a bulk density of 1.3 g cm^3 (1 acre-foot = 3.5 million lb). Organic soils (more than 20 percent organic matter) have lower bulk density (0.6 to 0.8 g cm^3).

What is whole farm nutrient management?

The goals of whole farm management are: (1) to move toward a balance of nutrient imports and exports, and (2) to utilize nutrients on the farm at agronomic rates that minimize nutrient losses to the environment. Managing nutrients at the whole farm level requires knowledge of the major nutrient imports, major nutrient exports, crop

utilization of nutrients on the farm, and nutrient losses to air and water.

The Livestock and Poultry Environmental Stewardship (LPES) Curriculum, available through the Midwest Plan Service, includes a Web presentation of whole farm nutrient management principles and a worksheet for evaluating whole farm nutrient balance. See "For more information" (page 15) for details.

What is the role of post-harvest nitrate testing in connection with Comprehensive Nutrient Management Plans (CNMPs)?

CNMPs, developed by the Natural Resources Conservation Service (NRCS) or other nutrient management professionals under NRCS supervision, are broader than just nutrient management. Other components of a CNMP are: (1) manure and wastewater handling and storage, (2) land treatment practices, (3) record-keeping, (4) feed management, and (5) other waste utilization options.

Post-harvest nitrate test values may be used as part of a process to develop a new CNMP or to update an existing CNMP. The CNMP typically includes a plan for regular soil testing. Appropriate timing of the post-harvest nitrate test is critical (see "When to sample," page 2), while soil samples for P and K analysis may be collected any time of the year. Soil samples collected for the post-harvest nitrate test can be analyzed by routine agronomic soil testing procedures and used in developing plans for P and K utilization in a CNMP.

What are the implications of high nitrate concentrations in forages?

Nitrate in ensiled forages can interfere with normal fermentation processes, resulting in poor-quality forage. Forage nitrate affects the distribution of nitrogen compounds in silage. It is difficult to use the silage to formulate rations that meet cow needs for specific protein fractions. Enough nitrate is sometimes present in the silage itself to create a health risk to the animal. Grass silage that is greater than 21 percent crude protein should be tested for the level of nitrate-N. See Johnson et al. (2002) for interpretation of forage nitrate concentrations.

For more information

OSU Extension Service publications

Hart, J. 2002. A List of Analytical Laboratories Serving Oregon, EM 8677.

Marx, E.S., J. Hart, and R.G. Stevens. 1996. Soil Test Interpretation Guide, EC 1478.

Marx, E.S., N.W. Christensen, J. Hart, M. Gangwer, C.G. Cogger, and A.I. Bary. 1996. The Pre-sidedress Soil Nitrate Test (PSNT) for Western Oregon and Western Washington, EM 8650.

Sullivan, D.M., C.G. Cogger, and A.I. Bary. 1997. Which Test Is Best? Customizing Dairy Manure Nutrient Testing, PNW 505.

Sullivan, D.M., C.G. Cogger, and A.I. Bary. 1997. Date, Rate, and Place: The Field Book for Dairy Manure Applicators, PNW 506.

Many OSU Extension Service publications, as well as additional gardening information, may be viewed or downloaded from the Web (http://eesc.oregonstate.edu).

Copies of many of our publications and videos also are available from OSU Extension and Experiment Station Communications. For prices and ordering information, visit our online catalog (http://eesc.oregonstate.edu) or contact us by fax (541-737-0817), e-mail (puborders@oregonstate.edu), or phone (541-737-2513).

WSU Cooperative Extension publications

Bary, A.I., C.G. Cogger, and D.M. Sullivan. 2000. Fertilizing with Manure, PNW 533.

Daniels, C.H. 2002. Analytical Laboratories and Consultants Serving Agriculture in the Pacific Northwest, EB1578E.

Visit the WSU Cooperative Extension publications Web site at http://pubs.wsu.edu

Other resources

Gavlak, R.G., D.A. Horneck, and R.O. Miller. 1994. Plant, Soil and Water Reference Methods for the Western Region, WREP 125 (University of Alaska-Fairbanks).

Johnson, L., J. Harrison, F. Hoisington, and M. Bueler. 2002. Nitrate levels in grass silage. Washington State Dairy News 11(2). Available at: http://www.puyallup.wsu.edu/dairy/. Verified 1 August 2002.

Mahler, R.L. and T.A. Tindall. 1994. Soil Sampling, Bulletin 704 (University of Idaho Cooperative Extension System, Moscow, ID).

Midwest Plan Service. Livestock and Poultry Environmental Stewardship (LPES) Curriculum. Available at: http://www.lpes.org/. Verified 14 January 2002.

North American Proficiency Testing Program. Standard Reference Soil Samples (Soil Science Society of America, 677 S. Segoe Rd., Madison, WI 53711; phone: 608-273-8080; Web: http://www.soils.org).

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The authors acknowledge the involvement of the following individuals in development of portions of the publication:

Andy Bary, WSU Cooperative Extension, Puyallup, WA

Don Horneck, OSU Extension Service, Hermiston, OR

Joe Harrison, WSU Cooperative Extension, Puyallup, WA

John Gillies, Washington State NRCS, Lynden, WA

John Hart, OSU Extension Service, Corvallis, OR

Mary Staben, OSU Extension Service, Corvallis, OR

Orlando Schmidt, BC Ministry of Agriculture, Food and Fisheries, Abbotsford, BC

Robert Dyk, Thurston Conservation District, Tumwater, WA

Robert Stevens, WSU Cooperative Extension, Prosser, WA

Steve Campbell, Oregon NRCS, Portland, OR

Tom Gohlke, Oregon NRCS, Portland, OR

Valerie Oksendahl, Washington State NRCS, Spokane, WA

Review comments on a draft of the publication were provided by:

Aria Baker, Linn Conservation District, Tangent, OR

Brad Brown, University of Idaho, Parma, ID

Chris Clark and Chuck Timblin, Whatcom Conservation District, Lynden, WA

Dean Moberg, Oregon NRCS, Hillsboro, OR

Fred Likkel, David Haggith, and Joy Hawley, N3 Consulting, Lynden

Glenn Gately, Jefferson Conservation District, Port Hadlock, WA

Jerry Lemunyon, NRCS, Fort Worth, TX

Lee Ko, Oregon NRCS, Oregon City, OR

Marty Chaney, Washington State NRCS, Olympia, WA

Mike Gamroth, Animal Science, OSU, Corvallis, OR

Mike Gangwer, OSU Extension Service, Salem, OR

Shabtai Bittman, Agriculture and Agri-Food Canada, Agassiz, BC

Troy Downing, OSU Extension Service, Tillamook, OR

Wym Matthews, Oregon Department of Agriculture, Tillamook, OR

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Soil Test Interpretation Guide

E.S. Marx, J. Hart, and R.G. Stevens

Regular soil testing is an important element in nutrient management. You can use soil tests as a diagnostic tool or to identify trends through time. To obtain meaningful test results, you must sample soil correctly, at the same time each year, and you must maintain records. For more information, see EC 628, *How to take a soil sample. . .and why (*see "For more information," page 7).

Soil testing laboratories use different test methods, which may influence results and sufficiency ranges. Therefore, the sufficiency ranges in this publication are accurate only for the test methods listed.

Soil tests used to evaluate fertility measure the soil nutrients that are expected to become plant-available. They do not measure total amounts of nutrients in the soil. Measurements of total nutrient content are not useful indicators of sufficiency for plant growth, because only a small portion of the nutrients are plant-available.

Adequate soil nutrient levels vary depending on plant species. Similarly, plant tolerance of excessive nutrient levels, nutrient imbalances, or less-than-optimum growing conditions varies. If excessive nutrient levels exist, review management to determine the cause.

Nutrient concentrations vary with soil depth. Depth of sampling, therefore, affects test results. To determine the proper sampling depth, you must consider the purpose of the soil test. To estimate nutrient availability for a crop prior to planting, sample soil to the depth where most root activity will occur. Shallow sampling sometimes is used to evaluate surface conditions in perennial crops where fertilizers have been applied to the soil surface. Deep sampling may be necessary to diagnose problems in orchards.

Soil test values do not vary greatly from year to year. Drastic changes in test values may indicate an unrepresentative soil sample or a laboratory error. When in doubt, submit a new sample or ask the lab to repeat the analysis.

This publication provides general guidelines for interpreting soil test results. Fertilizer guides for many individual crops are available from your county office of the OSU Extension Service or Washington State University Cooperative Extension, or from Extension and Experiment Station Communications, Oregon State University (see "For more information").

Nitrogen (N)

Plant-available nitrogen (nitrate and ammonium)

Plant-available forms of nitrogen are nitrate (NO_3^--N) and ammonium (NH_4^+-N). Soil concentrations of NO_3^--N and NH_4^+-N depend on biological activity, and therefore fluctuate with changes in conditions such as temperature and moisture. Nitrate is easily leached from the soil with high rainfall or excessive irrigation. Soil tests can determine NO_3^--N and NH_4^+-N concentrations at the time of sampling, but do not reflect future conditions.

When you collect samples for nitrogen testing, keep them cold, or dry them immediately to prevent NO_3^--N and NH_4^+-N concentrations from changing.

E.S. Marx, former research assistant in soil science, and John Hart, Extension soil scientist, Oregon State University;
and Bob Stevens, Extension soil scientist, Washington State University.

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Ammonium-nitrogen (NH_4^+-N)

Ammonium-nitrogen does not accumulate in the soil, as soil temperature and moisture conditions suitable for plant growth also are ideal for conversion of NH_4^+-N to NO_3^--N. Ammonium-nitrogen concentrations of 2–10 ppm are typical. Soil NH_4^+-N levels above 10 ppm may occur in cold or extremely wet soils, or if the soil contains fertilizer residue.

Nitrate-nitrogen (NO_3^--N)

West of the Cascades. Soil nitrate-nitrogen measurements are most useful as a post-harvest "report card" to evaluate N management. Nitrate remaining in the soil after harvest can leach during winter rains, contaminating surface and groundwater. If residual nitrate levels are consistently high, reduce fertilizer N inputs in future growing seasons.

Table 1.—Residual soil nitrate-nitrogen for evaluating N management.

	NO_3^--N in surface foot (ppm)*
low	<10
medium	10–20
high	20–30
excessive	>30

*See Table 13 (page 7) for conversion of ppm to lb/acre.

Mid-season measurement of soil nitrate is used for field corn production. See EM 8650, *The Pre-sidedress Soil Nitrate Test (PSNT) for Western Oregon and Western Washington*, for more information.

East of the Cascades. In arid regions, soil nitrate (NO_3^--N) is evaluated by measuring NO_3^--N to the expected rooting depth of the crop to be grown. If test results are reported in ppm, convert to lb/acre using Table 13 (page 7). Then subtract the soil nitrate from the crop requirement to determine a fertilizer rate.

Failure to account for NO_3^--N in the soil can lead to over-application of nitrogen fertilizers. Also, irrigation water should be analyzed for NO_3^--N content, and fertilizer rates reduced accordingly. Proper irrigation increases N use efficiency and reduces nitrate leaching.

Total nitrogen

Total nitrogen analysis measures N in all organic and inorganic forms. Total nitrogen does *not* indicate plant-available N, and is not included in standard soil testing programs.

A typical agricultural soil in the Willamette Valley contains about 0.10 to 0.15 percent N, or approximately 5,000 lb N/acre in the surface foot. Only 1 to 4 percent of this total N becomes plant-available during a growing season. East of the Cascades, soils tend to have smaller amounts of total N.

Total N analysis, while not recommended as part of a standard soil testing program, may be better than organic matter analysis for estimating soil N supplying capability.

Phosphorus (P)

The Bray P1 (for acid soils) and the Olsen sodium bicarbonate ($NaHCO_3$) (for alkaline soils) tests estimate plant-available phosphorus. Soil testing laboratories also use several other extraction methods. For interpretation of results from other extraction methods, contact the laboratory that performed the analysis.

Phosphorus soil tests are an index of P availability. The test values cannot be used to calculate available lb P_2O_5/acre.

When sampling soil, you must be aware of previous P management. Phosphorus is relatively immobile in soil. If phosphorus has been applied in a fertilizer band, concentrations of P may persist where the band was placed. Avoid fertilizer bands when collecting soil samples.

Table 2.—Phosphorus soil test.

	West of Cascades (Bray P1 test) ppm P	East of Cascades (Olsen test) ppm P
low	<20	<10
medium	20–40	10–20
high	40–100	20–40
excessive	>100	>40

The phosphorus application rate necessary to correct P deficiencies varies depending on soil properties. Phosphorus availability decreases in cool, wet soils. In many situations, banded phosphorus applications are more effective than broadcast applications.

Phosphorus applications generally are not recommended if tests are high or excessive. High soil phosphorus combined with surface runoff can cause excessive growth of plants and algae in surface waters, damaging aquatic ecosystems.

Cations

Of the three primary cations (potassium, calcium, and magnesium), potassium requires the most management attention. Few crops have responded to calcium and magnesium in the Pacific Northwest.

If extremely high levels of a single cation exist, plant deficiencies of other cations may occur due to competition for plant uptake.

The soil test ranges in Tables 3, 4, and 5 are for the ammonium acetate extraction method. If a sodium bicarbonate ($NaHCO_3$) extraction is used, test values may be slightly lower.

Potassium (K)

Excessive soil potassium levels can result in elevated K levels in grass forage crops, which may be detrimental to animal health.

Table 3.—Extractable potassium (K).

	K
low	<150 ppm* <0.4 meq/100 g soil
medium	150–250 ppm 0.4–0.6 meq/100 g soil
high	250–800 ppm 0.6–2.0 meq/100 g soil
excessive	>800 ppm >2.0 meq/100 g soil

*See Table 13 (page 7) for conversions from ppm to meq/100 g soil.

Calcium (Ca)

Calcium deficiencies usually are found only on very acid soils. They can be corrected by liming with calcium carbonate ($CaCO_3$).

Table 4.—Extractable calcium (Ca).

	Ca
low	<1,000 ppm* <5 meq/100 g soil
medium	1,000–2,000 ppm 5–10 meq/100 g soil
high	>2,000 ppm >10 meq/100 g soil

*See Table 13 (page 7) for conversions from ppm to meq/100 g soil.

Magnesium (Mg)

Magnesium deficiencies on acid soils can be corrected by liming with dolomitic lime.

Magnesium toxicity can occur on serpentine soils in southwest Oregon.

Table 5.—Extractable magnesium (Mg).

	Mg
low	<60 ppm* <0.5 meq/100 g soil
medium	60–180 ppm 0.5–1.5 meq/100 g soil
high	>180 ppm > 1.5 meq/100 g soil

*See Table 13 (page 7) for conversions from ppm to meq/100 g soil.

Sulfate-sulfur (SO_4^{2-}-S)

Plants absorb sulfur in the sulfate (SO_4^{2-}-S) form. In high rainfall areas west of the Cascades, SO_4^{2-} is readily leached, and soil test data are not well correlated with plant growth. In arid regions east of the Cascades, soil test information may be useful. Also, irrigation water may contain significant amounts of sulfate-sulfur. Plant analysis often is useful for diagnosing sulfur deficiency.

Table 6.—Sulfate-sulfur, east of the Cascades.

	SO_4^{2-}-S (ppm)
low	<2
medium	2–10
sufficient	>10

Micronutrients

Deficiencies of micronutrients other than boron and zinc are uncommon. Availability of most micronutrients is largely pH-dependent; availability decreases as pH increases (except for molybdenum, which becomes more available as pH increases). Deficiencies rarely occur in soils with pH below 6.5.

Soil testing for micronutrients other than boron and zinc is recommended only when a deficiency is suspected. If you suspect a micronutrient deficiency, plant tissue testing may be a better diagnostic tool than soil testing.

Boron (B)

Crops such as alfalfa, table beets, brassicas, caneberries, and root crops have responded to boron fertilization on B-deficient soils in western Oregon. Tree fruits and alfalfa are examples of crops sensitive to low boron levels east of the Cascades.

While low levels of boron may limit plant growth, high concentrations can be toxic. When applying boron, apply uniformly and mix thoroughly with the soil.

Table 7.—Boron by the hot water extraction method.*

	B (ppm)
low	<0.5
medium	0.5–2
high	>2

*The hot water extraction method for boron may result in incorrectly high values on soils with high organic matter content.

Zinc (Zn)

Zinc values above 1.0 ppm using the DTPA extraction method are sufficient. Zinc deficiencies have been identified in some crops in certain regions. Corn, beans, grapes, hops, onions, and deciduous fruit trees are especially sensitive to low levels of available zinc. Deficiencies sometimes are associated with high soil P concentrations, soils high in fine clay and silt, or soils with high pH.

Copper (Cu)

Copper values above 0.6 ppm using the DTPA extraction method are sufficient. Copper deficiencies are uncommon. Deficiencies have been identified on muck soils such as those in the Klamath area in Oregon and the Colville area in Washington.

Manganese (Mn)

Manganese values above 1.5 ppm using the DTPA extraction method are sufficient. Manganese deficiencies generally occur only in soils with pH 7.0 or above. Manganese toxicity may occur on acid soils. On alkaline soils east of the Cascades, Mn availability may increase in acidified microzones where fertilizers have been placed. These acidified microzones can alleviate Mn deficiencies sometimes encountered on high pH soils. In some instances, however, acidic microzones can result in Mn toxicity.

Iron (Fe)

Soil testing for iron is not recommended. Most test methods do not discern between forms of iron, and therefore have little meaning for plant nutrition.

Iron deficiencies are uncommon on acid soils in the Pacific Northwest. Where deficiencies occur, they often are associated with acid soil plants, such as azaleas or rhododendrons, growing on soils with unsuitably high pH. Acidifying fertilizers such as ammonium sulfate will help correct problems.

Iron applications on alkaline soils are inefficient unless a chelated form is used. Lowering soil pH to increase iron availability on a field scale is not economical. However, adding acidifying materials such as elemental sulfur to fertilizer mixes can acidify microzones around the fertilizer material and increase Fe availability.

Foliar applications of Fe sometimes are used to correct deficiencies in fruit, turf, and other high-value crops.

Molybdenum (Mo)

Soil Mo concentrations are too low for most labs to evaluate. Molybdenum deficiencies are rare, and are of concern mostly for leguminous crops. Molybdenum-deficient legumes appear chlorotic. Liming to raise soil pH may alleviate deficiencies. Molybdenum-coated seed also can be used.

Excessive molybdenum in forage can harm animal health. If you suspect excessive molybdenum in your forage, determine Mo content by forage analysis.

Chloride (Cl^-)

Soil testing for chloride is not a common practice, and little data exists for interpretation of test results. Evidence indicates that wheat sometimes benefits from chloride applications. The values in Table 8 are based on wheat research in Montana and South Dakota. Little information exists on chloride soil testing in Washington and Oregon.

Table 8.—Chloride soil test ranges for wheat in Montana and South Dakota, 2-foot sampling depth.

	ppm	lb/acre
low	0–4	0–32
medium	4–8	32–64
high	>8	>64

pH, lime requirement (LR)

Soil pH is a measure of soil acidity. Most crops grow best if the soil pH is between 6.0 and 7.5.

Table 9.—Soil pH ranges.

	pH
strongly acid	below 5.1
moderately acid	5.2–6.0
slightly acid	6.1–6.5
neutral	6.6–7.3
moderately alkaline	7.4–8.4
strongly alkaline	above 8.5

Soil pH can be increased by liming. The soil pH test indicates *if* lime is needed. The lime requirement test determines *how much* lime is needed. Accurate lime recommendations cannot be made without performing an SMP or similar test.

SMP* lime requirement test

The SMP lime requirement test is used to estimate the amount of lime required to raise the pH of 6 inches of soil. The SMP test is performed by mixing soil with a buffered pH 7.5 solution and determining the pH of the mixture. During the reaction, the soil's reserve acidity lowers the pH of the SMP solution. Soils with low SMP values have high reserve acidity and high lime requirements.

Some soils may have a low pH (<5.3) and a fairly high SMP buffer value (>6.2). This condition can be caused by the application of fertilizer. In this case, the low pH value is temporary, and the pH of the soil will increase as the fertilizer completes its reaction with the soil.

Sandy soils also may have a low pH and high SMP buffer value. This condition occurs because sandy soils have low amounts of reserve acidity due to low cation exchange capacity (CEC). In such cases, a light application of lime (1 to 2 t/a) should suffice to neutralize soil acidity.

Table 10 is used to determine the amount of lime required, based on the SMP test, to raise soil pH to a desired level. The target pH is determined by the crop to be grown and possibly by other factors.

*SMP stands for Shoemaker, MacLean, and Pratt—the people who developed the test.

Without an SMP or similar test, there is no way to know how much lime is required to adjust soil pH to a desired level. Accurate lime recommendations cannot be made solely on the basis of soil pH.

Table 10.—SMP lime requirement—field scale.

SMP buffer	Tons/acre of 100-score lime needed to raise pH of surface 6 inches of soil to the following pH's			
	5.3	5.6	6.0	6.4
6.7	—	—	—	—
6.6	—	—	—	1.1
6.5	—	—	1.0	1.7
6.4	—	—	1.1	2.2
6.3	—	—	1.5	2.7
6.2	—	1.0	2.0	3.2
6.1	—	1.4	2.4	3.7
6.0	1.0	1.7	2.9	4.2
5.9	1.4	2.1	3.3	4.7
5.8	1.7	2.5	3.7	5.3
5.7	2.0	2.8	4.2	5.8
5.6	2.3	3.2	4.6	6.3
5.5	2.6	3.6	5.1	6.8
5.4	2.9	3.9	5.5	7.3
5.3	3.2	4.3	6.0	7.8
5.2	3.6	4.7	6.4	8.3
5.1	3.9	5.0	6.9	8.9
5.0	4.2	5.4	7.3	9.4
4.9	4.5	5.8	7.7	9.9
4.8	4.8	6.2	8.2	10.4

Example: If the "SMP buffer" value is 5.9, the amount of lime needed to raise the pH to 6.0 is 3.3 tons of 100-score lime/acre.

Table 11.—SMP lime requirement—gardens.

If the SMP lime requirement test is	Apply this amount of lime (lb/1,000 ft²)
5.4 or below	250
5.5–6.0	150–250
6.0–6.5	100–150
above 6.5	0

Some plants, such as blueberries, rhododendrons, azaleas, and cranberries, grow best in acid soils. Fertilizers such as ammonium sulfate can help maintain acidic conditions.

Sodium (Na)

Sodium is not a plant nutrient and therefore is not necessary for plant growth. High levels of sodium are detrimental to soil tilth and plant growth.

Sodium levels are evaluated based on Exchangeable Sodium Percentage (ESP). The ESP is the percent of the cation exchange capacity (CEC) occupied by Na.

ESP values above 10 percent are of concern. Excessive sodium levels can occur naturally or can result from irrigation with high-sodium water. Reclamation involves establishment of drainage followed by gypsum application and leaching with low-sodium water.

Soluble salts (SS)

Soluble salt problems usually are associated with arid regions such as eastern Oregon and Washington. Soils with high levels of soluble salts are called saline soils. Soils high in sodium are called sodic soils (see "Sodium"). Saline-sodic soils are high in both soluble salts and sodium. Soluble salts are measured by electrical conductivity (EC) of a saturated paste soil extract.

Table 12.—Soluble salts.

	Conductivity (mmhos/cm*)	ppm salt**
low	<1.0	<640
medium	1.0–2.0	640–1,280
high	>2.0	>1,280

*mmhos/cm is equivalent to decisiemen/m.

**Multiply mmhos/cm by 640 to estimate ppm salt.

Because salts move readily with water, salt problems often are transient. Salt toxicity can occur, and salts may leach before soil is tested. Low salt values, therefore, do not always rule out salt toxicity as a cause of problems.

Salt tolerance varies greatly among plant species. Seedlings are especially sensitive to high salt concentrations. Excessive salts may inhibit seed germination. Excessive fertilization and poor irrigation water quality are sources of salts.

Organic matter

Maintenance of soil organic matter is one of the most important goals of soil management. Accurate measurement of soil organic matter is difficult.

Many laboratory methods are used. Most methods are indirect; they measure soil carbon and make an assumption about the percent carbon content of organic matter. The Walkley-Black method is common and gives consistent results. The loss on ignition method can give inconsistent results and tends to overestimate organic matter.

When estimating potential nitrogen release of a soil, total N testing is preferred to organic matter determination. Neither approach provides accurate estimates of soil N availability. If you are monitoring changes in organic matter over time, use the same lab for all analyses.

Cation exchange capacity (CEC)

CEC is a measure of a soil's capacity to retain and release elements such as K, Ca, Mg, and Na. Soils with high clay or organic matter content tend to have a high CEC. Sandy soils have a low CEC. Soil CEC is relatively constant over time, so there is no need for repeated analyses.

CEC often is determined by the ammonium acetate (NH_4OAc) or sodium acetate (NaOAc) methods. While these methods are standard in many regions, there are potential sources of error. Errors are most likely to occur for soils containing appreciable amounts of $CaCO_3$ or gypsum.

Some labs estimate CEC based on soil texture, organic matter content, cations, and pH. Such estimates often are inaccurate. The "sum of bases" method for calculating CEC of alkaline soils can give inaccurate results, especially if there are significant amounts of free $CaCO_3$.

CEC determination can be important for predicting behavior of pesticides and other chemicals in soils.

Base saturation

Base saturation is the percentage of the CEC that is occupied by cations other than hydrogen (H) and aluminum (Al). Soils with low base saturation generally are acidic. Base saturation and pH increase together.

For more information

Hart, J. *Analytical Laboratories Serving Oregon*, FG 74 (Oregon State University, Corvallis, reprinted 1997). No charge

Hart, J. *How to take a soil sample. . .and why,* EC 628 (Oregon State University, Corvallis, revised 1995). No charge

Marx, E.S., N.W. Christensen, J. Hart, M. Gangwer, C.G. Cogger, and A.I. Bary, *The Pre-sidedress Soil Nitrate Test (PSNT) for Western Oregon and Western Washington*, EM 8650 (Oregon State University, Corvallis, reprinted 1997). 75¢

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Table 13.—Conversions.

To convert column 1 into column 2, *divide* by	**Column 1**	**Column 2**	**To convert column 2 into column 1, *multiply* by**
390	ppm K	meq K/100 g soil	390
200	ppm Ca	meq Ca/100 g soil	200
121	ppm Mg	meq Mg/100 g soil	121
230	ppm Na	meq Na/100 g soil	230
1	meq/100 g soil	cmol/kg soil	1
2*	lb/acre (7 inch depth)	ppm	2*
3.65*	lb/acre (1 foot depth)	ppm	3.65*
43.56	lb/acre	lb/1,000 sq ft	43.56
43,560	square feet	acres	43,560
2.471	acres	hectares	2.471

*These values vary with soil bulk density.

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NUTRIENT MANAGEMENT
FOR DAIRY PRODUCTION

Which test is best?

Customizing dairy manure nutrient testing

D. Sullivan, C. Cogger, and A. Bary

Manure is a nutrient resource. To get the most value from this resource, you need accurate information on manure nutrient content. A regular manure testing program will:

- Help you save money on fertilizer
- Assist in refining application rates to meet, but not exceed, crop needs
- Demonstrate your commitment to protecting surface and groundwater quality
- Establish the value of manure for off-farm marketing
- Serve as a reliable data source for long-term farm plans

Both laboratory analyses and on-farm quick tests of manure nutrient content play an important role in manure management. Laboratory testing is the most reliable method of manure nutrient testing and is valuable for long-term planning and as a check on quick test results. Quick tests are valuable for rapid assessment of manure N content. Quick tests help guide daily management decisions.

Dan M. Sullivan, Extension soil scientist, Oregon State University; Craig G. Cogger, Extension soil scientist, Washington State University; and Andy I. Bary, scientific assistant, Washington State University.

This publication discusses the following aspects of a successful manure testing program:

- Collecting a manure sample that reflects average nutrient composition
- Selecting an analytical laboratory
- Requesting key nutrient analyses and usable reporting units from analytical labs
- Determining testing needs for different manure handling and storage systems
- Choosing on-farm tests for manure N content

On-farm quick tests determine manure N content within a few minutes.

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Manure application plans often are based on average manure analyses for a particular manure handling and storage system. However, manure nutrient composition also is related to your specific management practices, including:

- Source and quality of feed
- Water added to manure
- Type and amount of bedding
- How long the manure is stored

Because these factors often vary during the year, manure nutrient content also varies.

The importance of nitrogen

Nitrogen (N) usually is the most important nutrient in a manure testing program. Farm management plans approved by your local conservation district, the Natural Resources Conservation Service, or the Oregon Department of Agriculture require an agronomic manure application rate. The agronomic rate usually is based on N. Agronomic rates supply appropriate amounts of plant-available N for crop growth without excessive loss of nitrate to groundwater.

Crops take up N from the soil in the ammonium or nitrate forms (plant-available N). Manure usually contains little or no nitrate as applied. Nitrogen in manure usually is present as ammonium and organic forms (amino acids, proteins, etc.). Manure ammonium-N is plant-available immediately after application. Soil microorganisms slowly convert manure organic N to plant-available forms after application.

Manure analytical methods determine total N and ammonium N. Organic N is not measured directly. It is calculated as the total N content minus the ammonium-N content.

You can use nitrogen analyses of manure for both long-term planning and short-term decision making. First, analyses collected over a period of years serve as a good data source for long-term farm plans (e.g., determining land area needs for manure utilization). Second, you can use analyses to guide daily management decisions (e.g., calculating an application rate for a particular field). Simple, rapid on-farm testing procedures are well-suited for daily management decisions.

Effect of manure storage and handling on nitrogen content

How predictable is manure N content from your operation? The more variable the manure, the more samples you need to accurately characterize manure N content. Factors contributing to variability include:

Storage. Generally, the longer manure is stored, the higher the proportion of total N in the ammonium form, which is immediately available to plants. Organic N in stored manure is converted to ammonium-N by microbes; some of the ammonium-N then is lost as ammonia-N to the atmosphere.

Drying. Dried manure generally is low in ammonium-N; it is lost as ammonia during the drying process. Drying increases manure total N concentration (per unit volume).

Dilution. The more water added to manure, the lower its nutrient content. If you periodically add fresh water to a lagoon for summer irrigation, manure N content is reduced. Straw or other bedding materials usually are low in N and also reduce manure N concentration.

Tables 1 through 4 summarize the range in nutrient analyses for different manure-handling systems in the Pacific Northwest. We make the following observations:

Lagoon liquid pumped without agitation usually contains less than 5 lb N/1,000 gal; most of the N is in the ammonium form. Average total N content reported for two-cell Yakima Valley lagoons is 2.0 lb N/1,000 gal (Stevens and Prest, 1992, unpublished data). This is considerably lower than the average content reported for two-cell Willamette Valley lagoons, which is 4.4 lb N/1,000 gal (Table 1).

Agitated slurry from a lagoon or storage tank is highly variable; its N content varies with the total solids content of the slurry (Table 2).

Dry stack manure can have highly variable N contents because of variability in straw and moisture content (Table 3).

Separated manure solids from a mechanical separator are quite uniform in N content across a variety of separator and bedding types (Table 4).

Composted dry stack manure or composted separated solids are quite uniform in N content. Piles are mixed repeatedly during the composting process.

Table 1.—Nitrogen content of secondary lagoon liquid.[a]

Dairy	Usual range[b]		
	Low	High	Average
	lb N/1,000 gal		
A	3.0	6.0	4.4
B	1.8	3.5	2.6
C	3.0	6.0	4.9
D	2.0	7.0	4.2
E	3.0	6.0	4.9
F	3.0	7.0	5.6
G	3.0	4.5	3.8
H	3.5	6.0	5.0
Average	2.8	5.8	4.4

[a]Source: Gangwer, M., and M. Graham, 1994.

[b]"Usual range" contains 80 percent of monthly measurements over a 2-year period (locations A-E), or a 1-year period (locations F-H). Nitrogen determined via an Agros meter. For these lagoons with less than 1 percent total solids, Agros nitrogen was approximately equal to total nitrogen.

Table 2.—Nutrient content of dairy slurries from agitated lagoons or agitated storage pits.[a]

Total solids	Total N	Total P	Total K
%		lb/1,000 gal	
2	6–10	1.4–2.0	7–15
4	10–14	2.8–3.4	10–18
6	14–18	4.0–4.8	14–22
8	18–24	5.2–6.2	17–25

[a]Source: Sullivan, et al., 1994. Based on 37 analyses (Whatcom County, WA). Average total N was 3.7 percent, average total P was 0.9 percent, and average total K was 4.4 percent on a dry weight basis.

Table 3.—Nutrient content of dry stack manure.[a]

Nutrient	Analysis	
	Average	Standard deviation
	% (dry matter basis)	
Total N	1.3	0.30
Total P	0.81	0.19
Total K	1.86	0.51
	lb/wet ton (as-received basis)[b]	
Total N	8.6	1.6
Total P	4.0	0.8
Total K	13.1	2.8

[a]Source: Stevens, R.G., and V.I. Prest, 1992, unpublished data. Analyses are an average of composite samples from 14 dry stack facilities in the Yakima Valley (WA).

[b]lb/wet ton based on an average total solids content of 35 percent (65 percent moisture). Standard deviation in total solids content was 8 percent.

Table 4.—Nutrient content of separated manure solids.

Nutrient	Analysis			
	Oregon[a]		Washington[b]	
	% (dry matter basis)			
Total N	1.2	(0.28)[c]	1.5	(0.33)
Total P	0.21	(0.11)	0.26	(0.15)
Total K	0.46	(0.22)	0.51	(0.26)
C:N Ratio	33.1	(7.0)	25.6	(5.0)
	lb/wet ton (as-received basis)[d]			
Total N	4.6		5.6	
Total P	0.8		1.0	
Total K	1.7		1.9	

[a]Source: Gangwer, M., and M. Graham, 1995. Analyses are an average of 51 Willamette Valley (OR) facilities.

[b]Source: Sullivan, D., and H. Bierlink, 1992, unpublished data. Analyses are an average of nine Whatcom County (WA) facilities.

[c]Values in parentheses are standard deviations in dry matter nutrient analyses.

[d]lb wet/ton based on an average total solids content of 19 percent (81 percent moisture). Standard deviation in total solids content was 4 percent.

Collecting samples and choosing a test

You can analyze composite samples by on-farm quick tests or ship them to an analytical laboratory for analysis. We recommend using both laboratory and quick tests.

Quick tests are less precise than laboratory analyses. You can use quick tests frequently during the application season to check the variability in manure nutrient content. Use laboratory tests periodically to:

- Check the accuracy of the quick test results
- Obtain nutrient analyses not provided by the quick tests

See "Setting up a sampling program for your farm" for a detailed discussion of when to choose a laboratory analysis and when to use a quick test.

Collecting samples

Collecting a sample that represents the average composition of a manure source (lagoon, dry stack, etc.) is essential in obtaining accurate information from manure analyses. Usually, a number of individual samples are collected and mixed together to make a composite sample, which is analyzed for nutrient content.

The choice of sample collection methods depends on the kind of manure storage or application equipment. The greater the potential variability in manure composition, the more individual samples ("grab" samples) you should mix to obtain a composite sample. Call upon local experts (extension agents, conservation district or NRCS staff, private consultants) to assist you in designing an appropriate sampling strategy for your dairy.

For liquid manure, sample agitated manure immediately before application. Some operators have installed sampling ports in irrigation lines, so liquid manure can be easily sampled as it is pumped.

Sprinkler-applied liquid also can be collected in buckets placed in the field. Samples collected after sprinkling usually have lower ammonium-N content because of ammonia volatilization.

For solid manure, take 10–20+ small grab samples from the pile to make one composite sample. If piles have substantially different amounts of bedding, you will get better information by taking a separate composite sample from each pile.

After collection, thoroughly mix the grab samples and remove a composite sample (approximately 1 quart) for analysis.

Preparing samples for shipment to a lab

Preserve samples for laboratory analysis by refrigeration or freezing. Plan shipment so that samples are not left unrefrigerated over a weekend. Samples should arrive at the laboratory within 48 hours of shipment.

Check with your laboratory to discuss containers, preservation methods, and sample delivery schedules. Generally, laboratories prefer receiving samples in plastic containers with wide mouths and screw-top lids. Plastic bags are not recommended. (Nobody wants leaky manure samples!) Fill containers no more than two-thirds full to allow room for gases produced by fermenting manure.

Laboratory nutrient analysis

Description: Nutrient content determined via laboratory instruments.

Test procedure: Sample is homogenized, and analyses are run on a small subsample.

How it works: There are established procedures for each nutrient.

Manure type where it works best: Tests are valid for all forms of manure.

Nutrients estimated: Total N, ammonium-N, total P, total K, and total solids

Cost (for above analyses): $30–$60 per sample

Accuracy: Excellent. Major differences between laboratories usually are due to sample handling and preparation techniques, not analytical procedures.

Other comments: It is best to consistently use the same laboratory. See "Choosing a laboratory" for suggestions on selecting a laboratory, sample preservation, and shipping.

Choosing a laboratory

Find a lab that knows how to test manure and report results in a usable form. We suggest reporting manure analyses on both an "as-received" and a "dry weight basis" (Table 5). The "as-received" analysis can be used to determine application rates. The "dry weight" analyses can be used to track the consistency of manure nutrient composition over time. To develop a track record of manure analyses over time, use the same laboratory for each test.

To help you locate a suitable analytical laboratory, the Oregon State University Extension Service and Washington State University Cooperative Extension periodically compile lists of analytical laboratories serving the Pacific Northwest (see "Extension directories of analytical laboratories" at the end of this publication). Some extension and NRCS offices also have lists of laboratories doing business in their local areas.

Important questions to ask laboratory representatives include:

- Is the lab equipped to analyze manure samples for total N, ammonium-N, total P, total K, and total solids? How long will it take to provide results?
- How are analytical results reported? It's a good idea to obtain a sample laboratory report. Table 5 shows the preferred reporting units.
- How does the lab prepare the sample for analysis? For ammonium analysis, it is recommended that labs thoroughly mix and subsample wet samples. Drying samples prior to analysis results in loss of much of the ammonium-N.
- Does the lab participate in regional or national sample exchange programs coordinated by unbiased third parties (universities or trade associations)? Is the lab willing to share performance results from such sample exchange programs? Participation in sample exchange programs is a good indicator of a laboratory's commitment to precise and accurate results.

For composts marketed off-farm, we recommend additional analyses for pH, nitrate-N, cation exchange capacity, exchangeable bases (calcium, magnesium, potassium, and sodium), and conductivity (salinity). These analyses will help your customers successfully utilize compost.

Choosing an appropriate quick test

Quick tests are less precise than laboratory analyses. We recommend using both laboratory and quick tests (see "Setting up a sampling program for your farm"). Suggested applications for currently available quick tests are shown in Table 6.

Table 6.—Suggested on-farm quick tests for dairy manure N.

Type of manure	Hydrometer for total N	Nova meter for ammonium-N
Liquid less than 2% total solids	No	Yes
Liquid 2–6% total solids	Yes	Yes
Semi-solid 6–15% total solids	Yes[a]	Yes

[a]Sample must be diluted with water to 2–6 percent total solids; appropriate only for solid manure with little bedding; not suitable for separated solids.

Table 5.—Preferred reporting units for laboratory manure analyses. Results should be reported on both an "as-received" and "dry weight" basis.

Analysis	"As-received" basis		Dry weight basis
	Solid manure	Liquid manure	
Total solids[a]	%	%	
Total N, ammonium-N, total P, and total K	lb/wet ton	lb/1,000 gal	%[b]

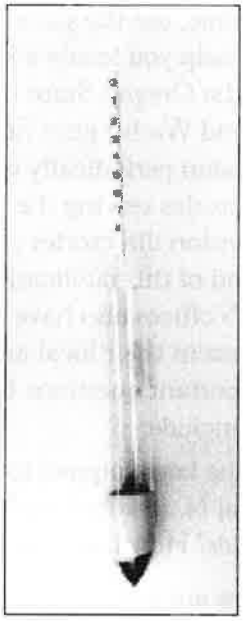
[a]Total solids is another way to express the moisture content of the manure "as-received." For example, a sample having 20 percent total solids would have 80 percent moisture content.

[b]For liquid manure with a total solids content less than 2 percent, laboratory nutrient analyses reported on a dry matter basis often have substantial variability. This usually is due to small differences in total solids analyses.

The hydrometer is a useful quick test for agitated lagoon slurry or semi-solid manure that has been scraped and stored in a pit or tank. Such manure sources, with solids contents above 2 percent, usually contain a substantial portion of their N in the solid part of the manure.

The hydrometer works best for slurries containing from 2 to 6 percent total solids. It is not appropriate for estimating the nutrient content of separated solids or of solid manure with large amounts of bedding.

On-farm quick test: Hydrometer



Description: Floating glass apparatus with a weighted bottom.

Test procedure: Collect a representative sample of slurry in a 5-gallon bucket. Stir to suspend solids. Place the hydrometer in the bucket and read the result after 15 seconds. If the slurry is too thick for the hydrometer to float freely, mix the slurry with water, stir well, and take a hydrometer reading. For a 1:1 dilution (water:slurry), double the hydrometer reading to get the correct value for undiluted slurry.

How it works: Measures the density (specific gravity) of liquid manure.

Manure type where it works best: Slurries, 2 to 6 percent total solids.

Initial cost: $30 to $60. No additional cost per sample.

Nutrients estimated: Total solids, total N, and total P.

Accuracy: Fair. We developed the following regression equations for agitated manure slurries (Sullivan, et al., 1994):

Total N (lb/1,000 gal) = 3.7 + 2.14 x (percent total solids), $R^2 = 0.72$
Total P (lb/1,000 gal) = 0.42 + 0.66 x (percent total solids), $R^2 = 0.84$

These regression equations were based on 37 composite samples collected from dairies in Whatcom County, WA over a 4-month period. Our regression equations for the hydrometer are similar, but not identical, to those previously reported for dairy slurry from North Carolina (Chescheir, 1985).

If your hydrometer is calibrated in units of specific gravity, use this table to estimate total solids:

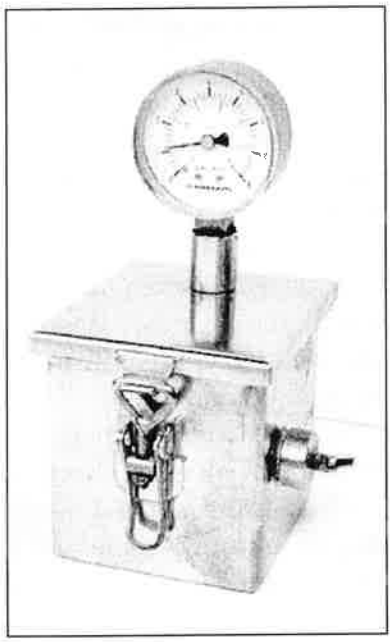
Specific Gravity	Total Solids (%)
1.011	2.0
1.020	4.0
1.028	6.0

Other comments: To use a hydrometer to estimate slurry nutrient content, you must have a calibration equation to relate slurry density to nutrient content. Calibration equations given in this publication are valid only for dairy manure. Hydrometers are available that read out in units of specific gravity, percent total solids, or percent total N. Measurement scales for hydrometers that read out in units other than specific gravity are based on manufacturers' regression equations.

The hydrometer measures slurry density and estimates total slurry N via a regression equation (see page 6). It also provides an estimate of slurry P content.

The Nova meter, which measures only ammonium-N, provides a helpful quick test for the N that is immediately plant-available. It is the quick test of choice for lagoon liquids, which contain most of their N in the ammonium form.

On-farm quick test: Nova meter or Agros meter



Description: Stainless steel or plastic chamber with a built-in pressure gauge. The Nova meter (plastic chamber) is a recent replacement for the Agros meter (stainless steel chamber). Both Nova and Agros meters use the same chemical process to estimate manure N.

Test procedure: Add manure to the main chamber using the scoop provided by the manufacturer. Add hypochlorite reagent to a separate reservoir inside the chamber. After the lid is secured, mix the hypochlorite and the manure inside the chamber following the manufacturer's instructions. Wait 2–5 minutes. Manure N content is given on the pressure gauge.

How it works: Hypochlorite oxidizes ammonium-N to form nitrogen gas (N_2) inside the chamber. The higher the manure ammonium-N, the more pressure is generated. The pressure gauge is calibrated by the manufacturer to read out in units of N.

Manure type where it works best: This quick test gives results very similar to a laboratory ammonium-N analysis. Use for manure where ammonium-N is a major proportion of total N. This is the best quick test for liquid manure with less than 2 percent solids.

Cost: Initial cost is $350 to $500. Hypochlorite reagent is consumed with each test.

Nutrients estimated: Ammonium-N only.

Accuracy: Excellent (See Sullivan, et al., 1994; Chescheir, et al., 1985).

Caution: Hypochlorite reagent is hazardous to eyes and irritates the nose and skin. Protect yourself with safety glasses, gloves, and a dust mask. Perform the tests outdoors in a well-ventilated area. Hypochlorite also is corrosive. Rinse metal parts with water after each use. Don't dispose of excess reagent in the garbage; it is a strong oxidizer.

Other comments: On some Nova or Agros meters, the pressure gauge has units of kg N/m^3. To convert kg/m^3 to lb/1,000 gal, multiply by 8.34.

Setting up a sampling program for your farm

Manure from different handling systems (dry stack, lagoon liquid, etc.) should be sampled and analyzed separately. The amount of time and money devoted to sampling manure from different sources should reflect its relative importance as a nutrient source and its potential variability. The more variability, the more sampling is required. Samples collected close to the time of application best reflect the nutrients applied to the field.

Let's take a look at how the general principles of manure sampling and testing apply to a specific dairy operation. For our example, let's consider a large dairy in western Washington or western Oregon with a flush barn-cleaning system, a mechanical solids separator, and a two-cell lagoon. Manure is generated from three sources: the separated solids, the secondary lagoon liquid, and periodic agitation of the primary and secondary lagoon for solids removal.

The suggested sampling plan is shown in Table 7 and is discussed below. To check the accuracy of the quick tests (Nova meter and hydrometer), we recommend splitting a composite sample once each year and analyzing it via both laboratory and quick test methods.

Secondary lagoon liquid. For this dairy operation, the most frequent manure application is in the form of secondary lagoon liquid. A yearly laboratory test is recommended to serve as a reliable record of the nutrient value of the secondary liquid (see Table 5 for recommended analyses). The samples for laboratory analysis can be taken at almost any time, but are most useful if taken when the lagoon is at least half full.

Since the secondary lagoon liquid contains N primarily in the ammonium form, its N content can be estimated using a Nova meter. Testing with the Nova meter can be used throughout the application season to refine application rates. It is especially helpful in the summer when the operator mixes secondary lagoon effluent with fresh irrigation water.

Agitated lagoon slurry. Each spring, the operator agitates the lagoon to remove accumulated solids from the bottom. The slurry produced by agitation is much higher in N content because of the suspended solids. We recommend at least one laboratory analysis per year. A hydrometer can be used on a daily or weekly basis to measure changes in N content due to differing amounts of suspended solids.

Separated solids. The nutrient analysis of the separated solids is not expected to vary significantly from published values (Table 4). Furthermore, for the current growing season, the separated solids represent only a small risk of excess N application, because most of the N is present in organic compounds that are slow to release plant-available N. Therefore, using average analytical values for separated solids (Table 4) is acceptable. We do not recommend routine testing of separated solids for on-farm utilization.

Table 7.—Example of a yearly sampling plan utilizing both laboratory and on-farm quick test methods.[a]

Manure applied as:	Application period	Suggested test frequency	
		Lab test	Quick test
Secondary lagoon liquid	April–Sept.	yearly	Nova—monthly
Separated solids	April–Sept.	none	none
Agitated lagoon slurry	April–May	yearly	Hydrometer—weekly

[a]Example location: western Oregon/Washington. Two-cell lagoon storage with solids separator.

Calculating manure application rates

A manure analysis is only part of the information you need for site-specific estimates of appropriate N application rates (volume or weight per acre). Other information needed includes:

- Crop N requirement
- Proportion of manure-N that will be plant-available during the growing season (less than 100 percent)
- Quantity of N supplied from other sources (e.g., decomposition of soil organic matter, fertilizer N)
- Crop N uptake efficiency—proportion of plant-available N removed by the crop (less than 100 percent)

We suggest you work with an agronomist in calculating site-specific application rates. You can get a rough idea of appropriate manure N application rates by assuming that crop N uptake is approximately equal to the needed manure N inputs. An example of this approach is found in OSU Extension publication EM 8585, *Manure Application Rates for Forage Production* (Hart, et al., 1996). It is a reasonable approach if manure is applied every year to the same fields.

Periodic soil testing also helps you apply manure at rates that match crop requirements.

Manure testing as part of whole-farm nutrient management

Manure testing is a more powerful tool when used together with other tools for nutrient management. Records of feed inputs, field-by-field manure application amounts and timing, fertilizer applications, and soil and plant tissue test results are some of the other components of whole-farm nutrient management. When data from these sources are used together, you can consider environmental as well as economic consequences when making long-range management decisions.

The references listed at the end of this publication can help you get started with whole-farm nutrient management. Together with manure analyses, these tools can help you adjust manure management to meet economic and water-quality goals.

Suppliers for quick tests

Both hydrometers and Nova meters may be available for short-term use from your local conservation district or NRCS office.

Hydrometers

Whatcom Conservation District, 6975 Hannegan Rd., Lynden, WA 98264; phone: 360-354-2035.

Various laboratory supply companies. Choose a hydrometer used for measuring the specific gravity of soil suspensions. We recommend a model that is equivalent to ASTM #151H specifications (measures specific gravity from 0.995 to 1.038 g/cm^3).

Nova meters

Farm Home Offices, Inc. 1965 64th St., Box 840, Vinton, Iowa 52349; phone: 800-788-7218 (sells a version of the Nova meter called "On-the-farm manure nitrogen test kit").

Grass Roots Project Management, P.O. Box 136, Chilliwack, BC, Canada V2P 6H7; phone: 604-795-2350 (sells a version of the Nova meter called the "Nova MK2 meter").

For more information

Selected research publications

Chescheir, G.M., P.W. Westermann, and L.M. Safley. 1985. Rapid methods for determining nutrients in livestock manures. Transactions of the ASAE 28 (6): 1817–1824 (American Society of Agricultural Engineers, St. Joseph, MI).

Sullivan, D.M., H. Bierlink, and W. Matthews. 1994. Tools for getting more value out of dairy manure. pp. 55–65. In: Proc. 26th Annual Dairy Producers Short Course, Feb. 8–9, 1994, Clearbrook, BC, Canada. BC Ministry of Agriculture, Fisheries and Food, Chilliwack, BC (available from Dan Sullivan, Department of Crop and Soil Science, Oregon State University).

Manure analyses for Willamette Valley dairies

Available from:

M. Gangwer
Marion County Office
OSU Extension Service
3180 Center St. NE, Room 1361
Salem, OR 97301
Phone: 503-588-5301

Gangwer, M., and M. Graham. *Wastewater volume and nitrogen concentrations in Willamette Valley, Oregon dairy ponds*, SR 939 (Oregon State University, Corvallis, 1994). No charge.

Gangwer, M., and M. Graham. *Analysis of separated manure solids from selected manure separators in Willamette Valley, Oregon dairy facilities*, SR 945 (Oregon State University, Corvallis, 1995). No charge.

Extension directories of analytical laboratories

See ordering instructions on page 11.

Hart, J. *A list of analytical laboratories serving Oregon*, EM 8677 (Oregon State University, Corvallis, 1997). No charge.

Schreiber, A., and C.H. Daniels. *Analytical laboratories and consultants serving the Pacific Northwest*, EB 1578 (Washington State University Cooperative Extension, Pullman, 1994). $1.50

Extension publications on whole-farm nutrient management

See ordering instructions on page 11.

Sullivan, D.M., C.G. Cogger, and A.I. Bary. *Date, rate, and place: The field book for dairy manure applicators*, EM/PNW 506 (Oregon State University Corvallis, 1997). $5.50

Gardner, E.H., and J. Hart. *How to take a soil sample . . . and why*, EC 628 (Oregon State University, Corvallis, revised 1995). No charge.

Grusenmeyer, D., and B. Peterson. *Manure management guidelines for western Washington* (Washington State University Cooperative Extension, Whatcom County, 1995). Available from Whatcom County Office, 1000 N. Forest, Bellingham, WA 98225.

Hart, J., M. Gangwer, M. Graham, and E. Marx. *Dairy manure as a fertilizer source*, EM 8586 (Oregon State University, Corvallis, reprinted 1997). 75¢

Hart, J., E.S. Marx, and M. Gangwer. *Manure application rates for forage production*, EM 8585 (Oregon State University, Corvallis, reprinted 1997). $1.00

Hermanson, R.E. *Manure sampling for nutrient analysis with worksheets for calculating fertilizer values*, EB 1819 (Washington State University, Pullman, 1996). $1.00

Hermanson, R.E., A.C.S. Rao, W.L. Pan, K.F. Duncan, and M.A. Wright. *MNB: Manure nutrient balancer* (computer software for IBM-compatible computers) (Washington State University, Pullman, 1995). Order number MCP 0026. $25.00

Marx, E.S., J. Hart, and R.G. Stevens. *Soil test interpretation guide*, EC 1478 (Oregon State University, Corvallis. reprinted 1997). $1.50

Marx, E.S., N.W. Christensen, J. Hart, M. Gangwer, C.G. Cogger, and A.I. Bary. *The pre-sidedress soil nitrate test (PSNT) for western Oregon and western Washington*, EM 8650 (Oregon State University, Corvallis, reprinted 1997). 75¢

Moore, J., and M.J. Gamroth. *Calculating the fertilizer value of manure for livestock operations*, EC 1094 (Oregon State University, Corvallis, reprinted 1993). $1.00

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Manure testing quick tips

A regular manure testing program will:

- Help you save money on fertilizer
- Assist in refining application rates to meet, but not exceed, crop needs
- Demonstrate your commitment to protecting surface and groundwater quality
- Establish the value of manure for off-farm marketing
- Serve as a reliable data source for long-term farm plans

Variability in manure analyses. The more variable the manure source, the more often you need to test it to characterize its nutrient content. This publication summarizes the variability observed for different manure handling systems in the Pacific Northwest. Use this information to budget your testing dollars.

Collecting samples for nutrient analysis. Collect a sample that represents the average composition of a manure source (lagoon, dry stack, etc.) to obtain accurate results.

Laboratory testing is the most reliable testing method. Find a lab that knows how to test manure and report results in a usable form. We recommend analysis for total N, ammonium-N, total phosphorus (P), total potassium (K), and total solids (moisture content). Ask the lab to report nutrient analyses on both an "as-received" and a "dry weight" basis.

Quick tests for nitrogen. Although laboratory tests are more accurate, quick tests provide information to guide daily management decisions. Two simple, rapid, on-site test procedures for N analysis are described in this publication (the hydrometer and the Nova meter). Verify quick test results with periodic laboratory analyses.

Calculating agronomic manure application rates. A manure analysis is only part of the information you'll need. An agronomist can help you calculate site-specific manure application rates to meet crop needs.

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NUTRIENT MANAGEMENT
FOR DAIRY PRODUCTION

Dairy manure as a fertilizer source

J. Hart, M. Gangwer, M. Graham, and E.S. Marx

Most dairies need no commercial fertilizer if they use manure properly. In most cases, manure can supply all the nitrogen, phosphorus, potassium, and several other nutrients needed for forage production.

More than half the nutrients in dairy rations are excreted in manure. The key to managing manure is to treat it as a resource by recycling these nutrients to produce forage. For example, one lactating dairy cow's manure can supply enough nitrogen for 1.5 acres of silage corn.

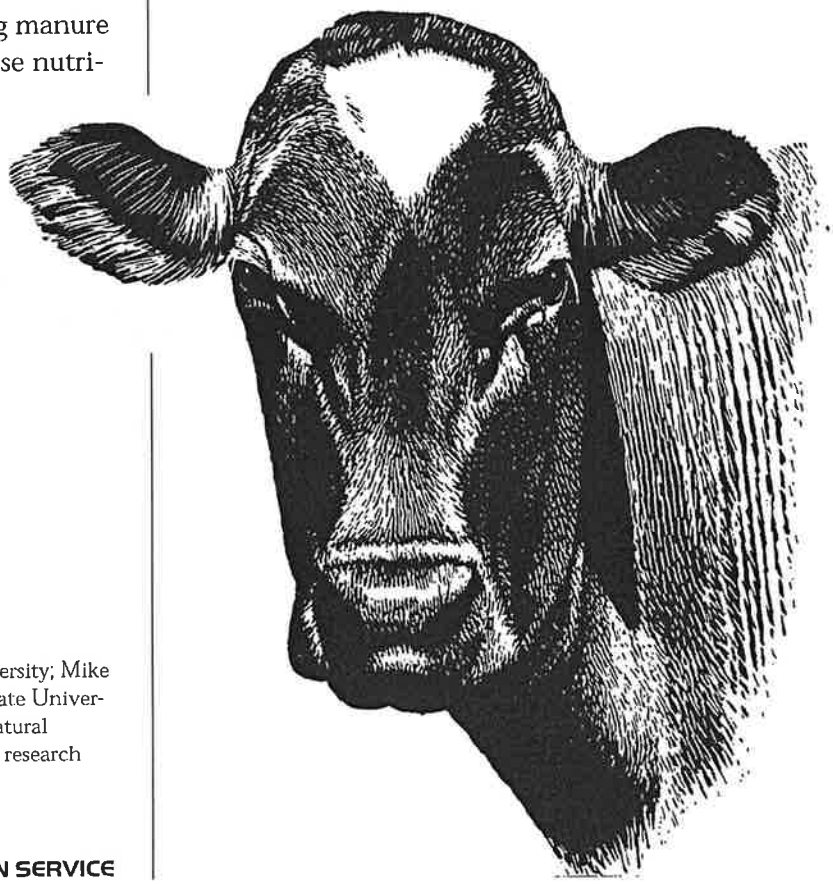
This publication examines several aspects of the nutrient content and value of dairy manure:

- Nutrient flow through a dairy
- Distribution of nutrients in manure
- Dairy manure nutrient content
- Value of manure

Nutrient flow through a dairy

Nutrients enter your farm in feed and fertilizer. Cows remove nutrients from feed for metabolism and milk production.

Some nutrients leave the farm in milk, but most are excreted in manure and remain on the farm. Manure applications return nutrients to the soil, where they can be reused to produce more feed.



John Hart, Extension soil scientist, Oregon State University; Mike Gangwer, Extension agent, Marion County, Oregon State University; Monte E. Graham, soil conservationist, USDA Natural Resource Conservation Service; and E.S. Marx, former research assistant in soil science, Oregon State University.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Figure 1 illustrates nutrient flow through a dairy.

Figure 2 shows a cow's daily feed intake and where the nutrients end up. ***Note that more than half the nutrients in feed are excreted in manure.***

Each year, a 1,400-pound lactating cow producing 70 pounds of milk per day excretes the following nutrients in manure:

- 300 pounds of nitrogen
- 45 pounds of phosphorus
- 165 pounds of potassium

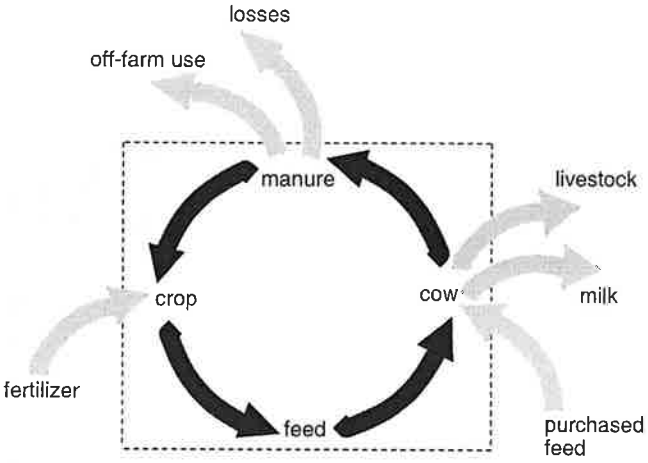


Figure 1.—Nutrient flow through a dairy.

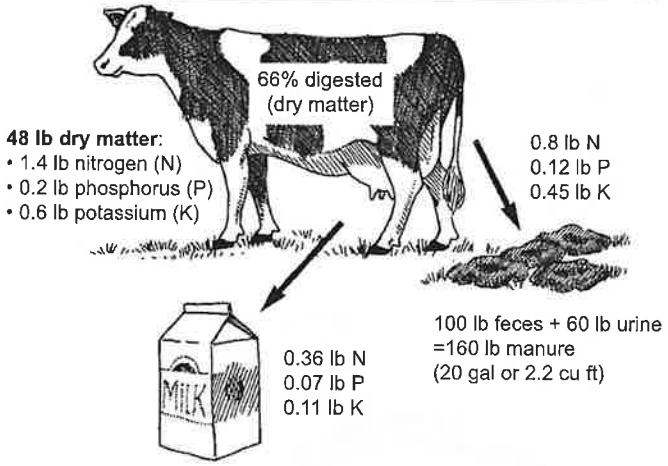


Figure 2.—Daily nutrient flow for a lactating cow.

Contrast these amounts to the smaller quantities of nutrients that leave the farm each year in milk:

- 100 pounds of nitrogen
- 20 pounds of phosphorus
- 30 pounds of potassium

Only 15 to 25 percent of the nutrients in feed end up in milk. The majority remain in manure, a valuable fertilizer resource for forage production. Figure 3 illustrates the proportions of nitrogen, phosphorus, and potassium excreted in manure and leaving the farm in milk.

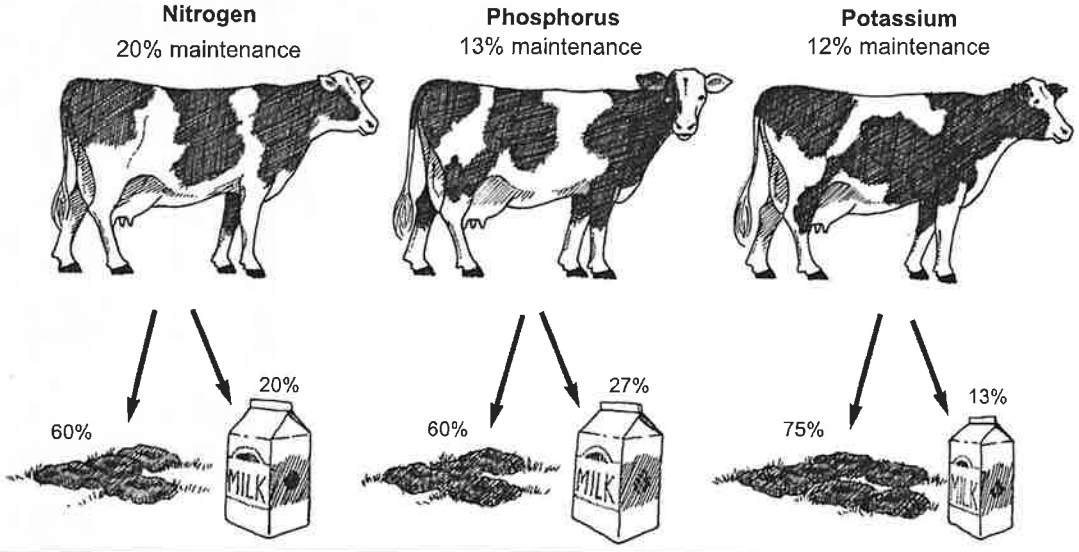


Figure 3.—Fate of nutrients in feed.

Distribution of nutrients

Not all nutrients are divided evenly between the feces and urine. Most of the phosphorus is found in the feces, while most of the potassium is excreted in the urine. Nitrogen is evenly divided between feces and urine. Figure 4 shows how the nutrient output is divided.

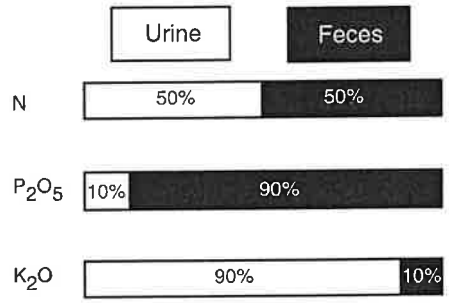


Figure 4.—Distribution of nutrients in manure.
Source: *Field Application of Manure, A Supplement to Manure Management for Environmental Protection*, Robert E. Graves, ed. (Pennsylvania Department of Environmental Resources, Harrisburg, 1986).

Dairy manure nutrient content

The *approximate* nutrient composition of manure in four common handling systems is shown in Table 1. Use Table 1 to estimate nutrient amounts remaining for crop use.

For example, 1 acre-inch of typical storage pond effluent provides more than twice the nitrogen needed for one cutting of grass forage or more than half the nitrogen needed for a corn silage crop.

Nutrient amounts are expressed in the same way as a fertilizer analysis:

- Total nitrogen (N)
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- Potassium (K) as K_2O

The second column in Table 1 indicates the amount of ammonium N (NH_4-N). Ammonium N is readily available to plants. Most of the nitrogen found in storage ponds is in the form of ammonium nitrogen, and therefore is available to crops.

In contrast, nitrogen in other forms is only slowly available to plants. This is why only half the nitrogen from separated solids is available to plants during the growing season.

Potassium from any of the sources is readily available to plants. Most of the phosphorus is available the season manure is applied.

Table 1.—Nutrient composition of dairy manure.

Manure Type	Total N Nitrogen	Ammonium Nitrogen	Total P_2O_5 Phosphorus	Total K_2O Potassium
Dry stack (lb/ton wet manure)	10	3	10	15
Separated solids (lb/ton wet solids)	5	NA[1]	2	2
Reception tank (lb/1,000 gallons)	20	8	7	18
Storage pond (lb/acre-inch)	135	109	30	135

[1]Little if any ammonium nitrogen is found in separated solids.

Sources of data: storage pond and separated solids—Willamette Valley, Oregon; dry stacks—Yakima area, Washington; reception tank—Whatcom County, Washington.

Sample and analyze manure from your dairy. Nutrient content varies widely from farm to farm. For example, Table 2 shows the low, average, and high nitrogen content of solids from 51 Willamette Valley separators. Nitrogen content varies almost sixfold from the low to high analysis.

Value of manure

Nitrogen generally is the limiting nutrient to plant growth and the most expensive to purchase. Nitrogen in commercial fertilizer costs approximately 30 cents per pound and $5 per acre to apply. Phosphorus costs 20 cents per pound, and potassium costs 15 cents per pound.

Figure 5 shows the annual fertilizer value of manure from 100 dairy cows. This illustration does not take into account loss during storage or handling or incomplete availability of nutrients.

If losses and incomplete availability are taken into account, ***the annual value of nutrients in manure from 100 lactating cows exceeds $10,000.***

Proper management of manure can increase farm profits and reduce risk of environmental damage.

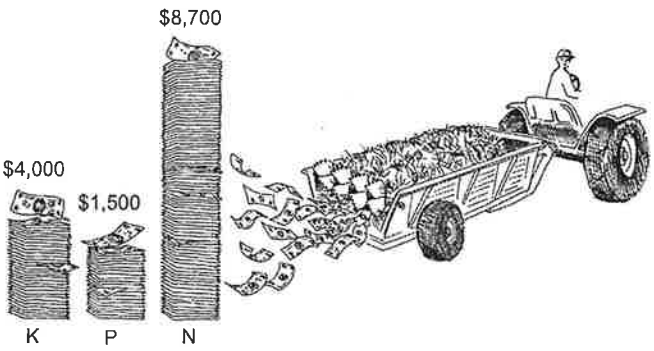

Figure 5.—Annual value of manure from 100 cows.

Table 2.—Nutrient contents from solids.

	Low	Average	High
Nitrogen (N)	0.29%	1.22%	1.88%
Phosphorus (P)	0.09%	0.21%	0.83%
Potassium (K)	0.09%	0.46%	1.34%

Based on samples from 51 Willamette Valley separators.

Source: *Analysis of Separated Manure Solids from Selected Manure Separators in Willamette Valley, Oregon Dairy Facilities*, SR 945, by Mike Gangwer and Monte Graham (Oregon State University, Corvallis, 1995).

For more information

The following publications can be ordered from:
Mike Gangwer
Marion County Office
OSU Extension Service
3180 Center St. NE, Room 160
Salem, OR 97301

Analysis of Separated Manure Solids from Selected Manure Separators in Willamette Valley, Oregon Dairy Facilities, SR 945, by Mike Gangwer and Monte Graham (Oregon State University, Corvallis, 1995). No charge.

Wastewater Volume and Nitrogen Concentrations in Willamette Valley, Oregon Dairy Ponds, SR 939, by Mike Gangwer and Monte Graham (Oregon State University, Corvallis, 1994). No charge.

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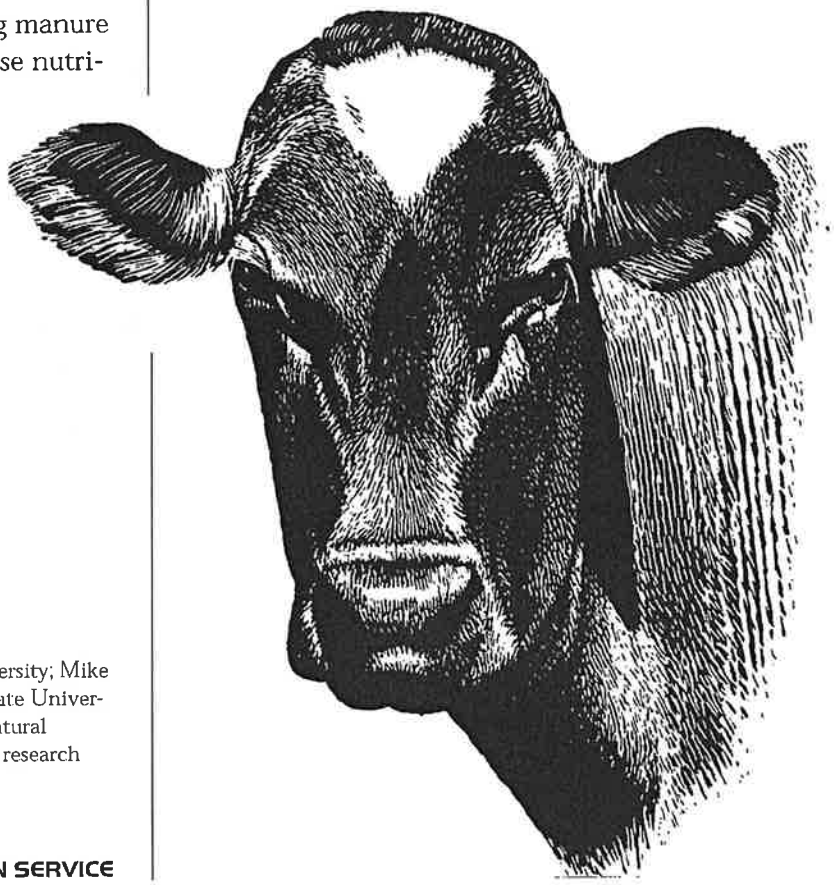

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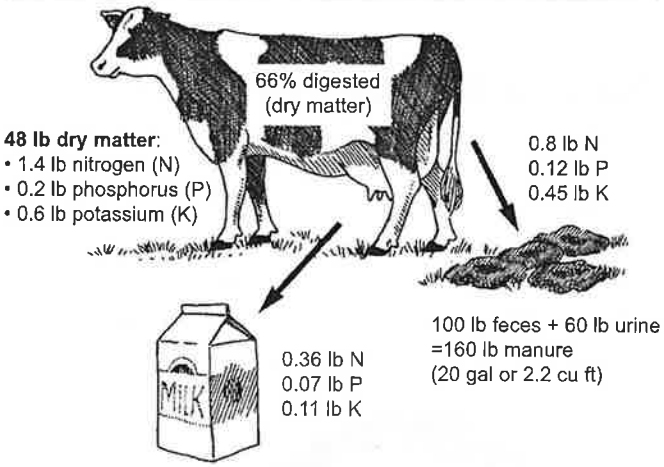

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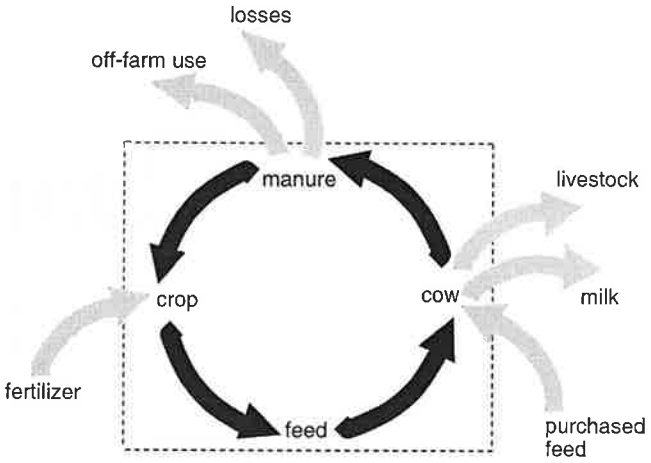

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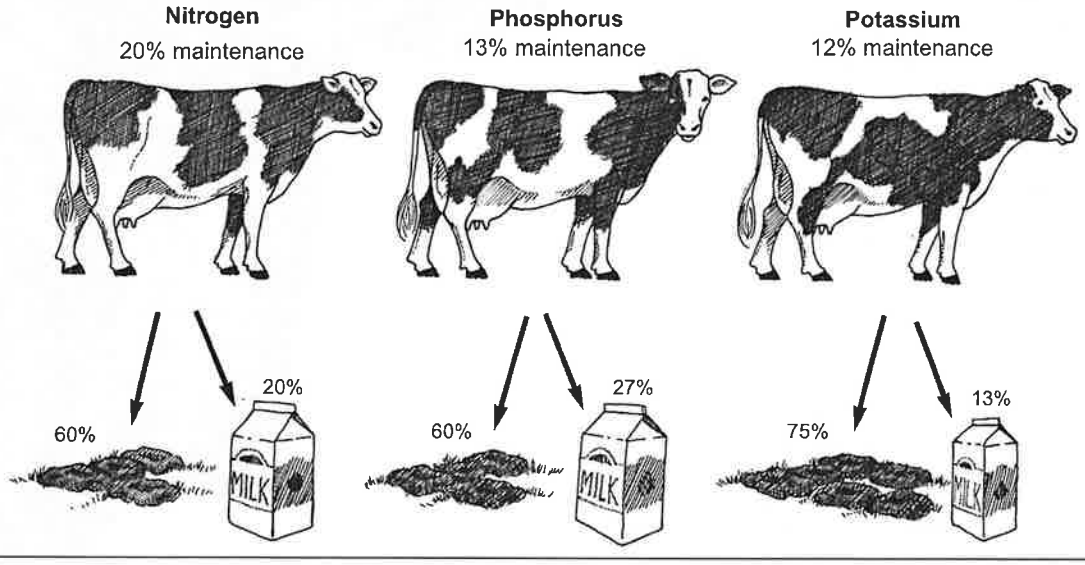

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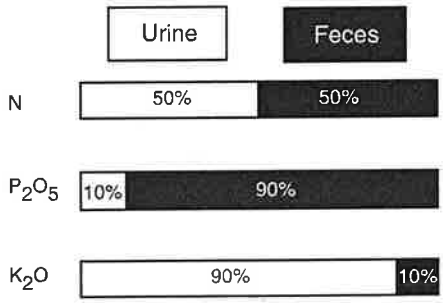

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The second column in Table 1 indicates the amount of ammonium N (NH_4-N). Ammonium N is readily available to plants. Most of the nitrogen found in storage ponds is in the form of ammonium nitrogen, and therefore is available to crops.

In contrast, nitrogen in other forms is only slowly available to plants. This is why only half the nitrogen from separated solids is available to plants during the growing season.

Potassium from any of the sources is readily available to plants. Most of the phosphorus is available the season manure is applied.

Table 1.—Nutrient composition of dairy manure.

Manure Type	Total N Nitrogen	Ammonium Nitrogen	Total P_2O_5 Phosphorus	Total K_2O Potassium
Dry stack (lb/ton wet manure)	10	3	10	15
Separated solids (lb/ton wet solids)	5	NA[1]	2	2
Reception tank (lb/1,000 gallons)	20	8	7	18
Storage pond (lb/acre-inch)	135	109	30	135

[1]Little if any ammonium nitrogen is found in separated solids.

Sources of data: storage pond and separated solids—Willamette Valley, Oregon; dry stacks—Yakima area, Washington; reception tank—Whatcom County, Washington.

Sample and analyze manure from your dairy. Nutrient content varies widely from farm to farm. For example, Table 2 shows the low, average, and high nitrogen content of solids from 51 Willamette Valley separators. Nitrogen content varies almost sixfold from the low to high analysis.

Value of manure

Nitrogen generally is the limiting nutrient to plant growth and the most expensive to purchase. Nitrogen in commercial fertilizer costs approximately 30 cents per pound and $5 per acre to apply. Phosphorus costs 20 cents per pound, and potassium costs 15 cents per pound.

Figure 5 shows the annual fertilizer value of manure from 100 dairy cows. This illustration does not take into account loss during storage or handling or incomplete availability of nutrients.

If losses and incomplete availability are taken into account, ***the annual value of nutrients in manure from 100 lactating cows exceeds $10,000.***

Proper management of manure can increase farm profits and reduce risk of environmental damage.

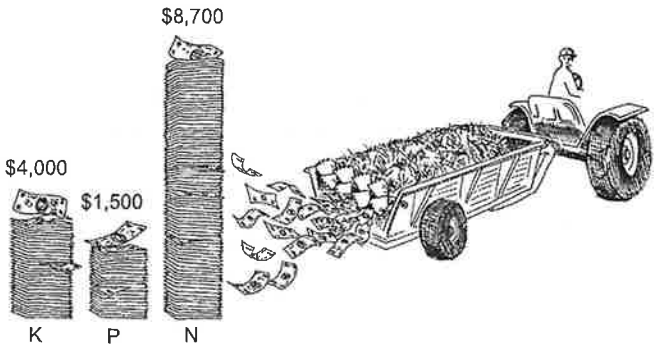

Figure 5.—Annual value of manure from 100 cows.

Table 2.—Nutrient contents from solids.

	Low	Average	High
Nitrogen (N)	0.29%	1.22%	1.88%
Phosphorus (P)	0.09%	0.21%	0.83%
Potassium (K)	0.09%	0.46%	1.34%

Based on samples from 51 Willamette Valley separators.

Source: *Analysis of Separated Manure Solids from Selected Manure Separators in Willamette Valley, Oregon Dairy Facilities*, SR 945, by Mike Gangwer and Monte Graham (Oregon State University, Corvallis, 1995).

For more information

The following publications can be ordered from:
Mike Gangwer
Marion County Office
OSU Extension Service
3180 Center St. NE, Room 160
Salem, OR 97301

Analysis of Separated Manure Solids from Selected Manure Separators in Willamette Valley, Oregon Dairy Facilities, SR 945, by Mike Gangwer and Monte Graham (Oregon State University, Corvallis, 1995). No charge.

Wastewater Volume and Nitrogen Concentrations in Willamette Valley, Oregon Dairy Ponds, SR 939, by Mike Gangwer and Monte Graham (Oregon State University, Corvallis, 1994). No charge.

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NUTRIENT MANAGEMENT
FOR DAIRY PRODUCTION

Manure application rates for forage production

J. Hart, E.S. Marx, and M. Gangwer

Most dairies can supply all the nitrogen, phosphorus, potassium, and other nutrients needed for forage production by applying manure to forage crops. As a manager, your goal is to match nutrient supply with crop needs by deciding when and how much manure to apply.

This publication explains how to estimate the amount of manure to apply for forage production. To do so, you need:

- A current manure analysis for your dairy (or see EM 8586, *Dairy Manure as a Fertilizer Source*)
- A list of forage crops to be produced
- A soil test from each field where manure will be applied

Too much manure results in excess plant uptake of nutrients such as potassium. High-potassium grass forages can lead to health problems, especially in dry cows. In addition, excess manure contributes to nutrients and microorganisms in runoff water and potential nutrient leaching to groundwater.

John Hart, Extension soil scientist; E.S. Marx, former research assistant in soil science; and Mike Gangwer, Extension agent, Marion County; Oregon State University.

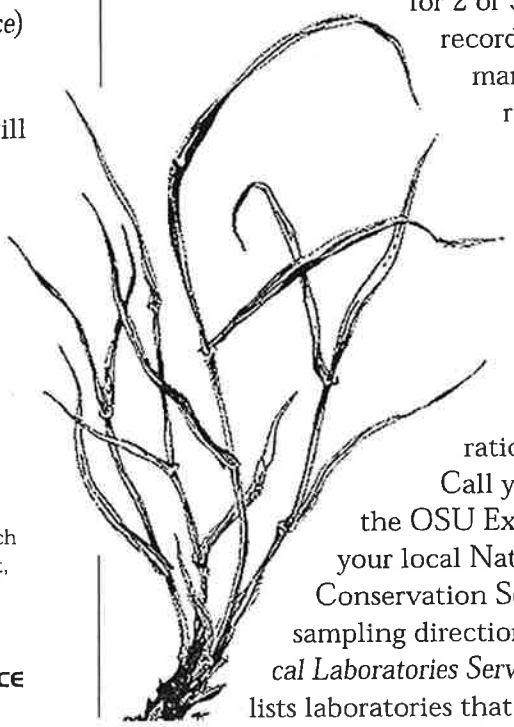
OREGON STATE UNIVERSITY EXTENSION SERVICE

The application rates in this publication are based on soil tests and growing conditions in western Oregon.

Manure analysis

Analyzing your manure is critical to determining the correct application rate. If you don't test your dairy's manure, you can only guess its nutrient value.

Manure testing in western Oregon has shown more variation among dairies than within one dairy. Develop a manure nutrient history for your dairy by testing manure two or three times a year for 2 or 3 years. These records will help you manage nutrient resources.



Also test manure when you expect a change in nutrient content; for example, when you make a large change in the ration.

Call your county office of the OSU Extension Service or your local Natural Resources Conservation Service office for sampling directions. *A List of Analytical Laboratories Serving Oregon* (FG 74) lists laboratories that test manure.

Crop nitrogen requirements

Nitrogen (N) is the nutrient needed for crop production on dairies. Tables 1 and 2 show the estimated nitrogen removal rate (or uptake) for average yields of the most common forage crops grown on dairies.

Determining manure application rate

Your goal is to match manure nutrient application rates with crop removal. Table 1 and Figures 1–3 provide the information you need for perennial crops, and Table 2 and Figures 4–6 apply to annual crops. Instructions on how to use them follow. (An example is illustrated on page 3.)

Perennial crops

1. In Table 1, find the crop you will grow and the average yield per cutting. Let's assume you grow perennial ryegrass. Table 1 shows that an average yield per cutting is 1.2 tons per acre of dry matter (about 3 tons of harvested grass).
2. Now find the nitrogen removal rate for the average yield. Table 1 shows that perennial ryegrass takes up about 60 pounds of N per acre for each cutting. Thus, you should apply about 60 lb N/a after cutting the ryegrass.
3. Find the figure below (Figures 1–3) that represents the type of manure you want to apply. Let's assume you want to apply lagoon effluent, so you'll use Figure 2.
4. Figure 2 contains three lines representing N application rates of 50, 100, and 150 lb N/a. Find the line that is closest to the rate you need to apply. You'll use the line for 50 lb/a because it is closest to 60 lb/a.
5. Select your manure analysis for nitrogen on the left side of the graph. Let's assume a manure test shows that the effluent contains 6 lb/1,000 gallons or 750 ppm N. Move to the right across the graph until you meet the line for the application rate you have chosen (50 lb N/a).

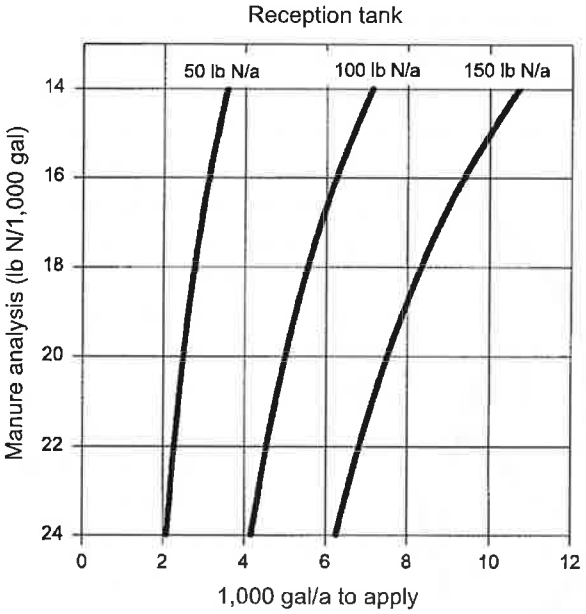


Figure 1.—Determining application rate for reception tank manure.

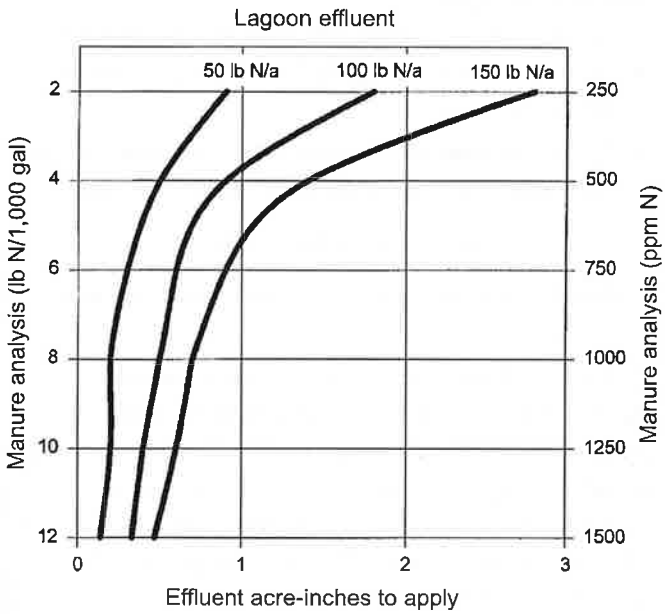


Figure 2.—Determining application rate for lagoon effluent.

Note: Recommendations in Figures 1–6 assume that nitrogen applications should not exceed crop removal. We assume that N mineralization will offset any volatile losses that occur during application.

Table 1.—Approximate nitrogen removal by perennial forage crops and suggested nitrogen application rates.

Crop	Average yield per cutting (t/a)	N removal rate for average yield per cutting (lb N/a)	Suggested N application rate (lb N/t of forage*)
Orchard grass	1.4	70	50–60
Perennial ryegrass	1.2	60	50–60
Tall fescue	1.4	70	50–60

*All rates are on dry matter basis unless noted otherwise.

6. Now move down to the line labeled "effluent acre-inches to apply." Estimate the number of acre-inches of effluent to apply (about 0.3 acre-inch). Remember that you will need about 10 percent more nitrogen because no line exists for the 60 lb N/a required by ryegrass. Your final result will be about 0.4 acre-inch.

Note: If you know your own yield per cutting, you can figure your nitrogen need more accurately. To do so, multiply your tons per acre per cutting by the "suggested N application rate (lb N/t of forage)" in Table 1. The result is your N removal rate. Use the line in the appropriate figure that is closest to that rate.

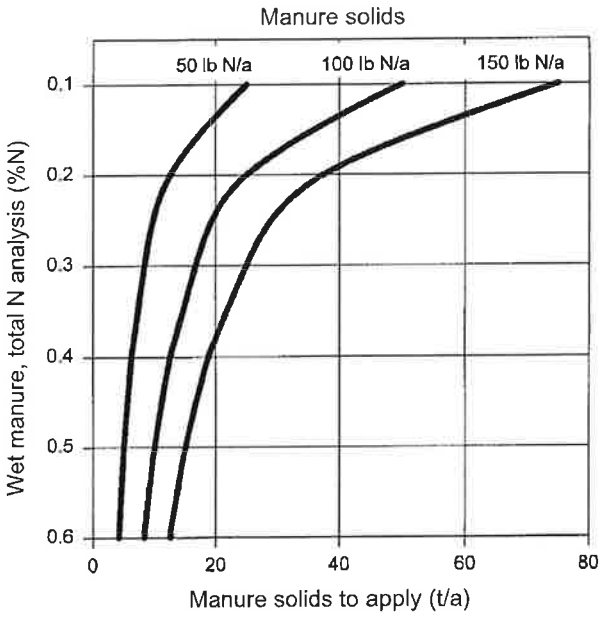


Figure 3.—Determining application rate for manure solids.

Example

Crop: perennial ryegrass

Manure: lagoon effluent

1. Average yield per cutting = 1.2 t/a (Table 1).
2. Nitrogen removal rate = 60 lb N/a per cutting (Table 1).
3. Find the lagoon effluent graph (Figure 2).
4. Use the 50 lb/a line because it is closest to the 60 lb/a you need to apply.
5. Your manure test shows 6 lb/1,000 gal. Find this line on the left of the graph. Move across to the 50 lb/a line.
6. Move down to the bottom line to find the number of acre-inches to apply (0.3 acre-inch).

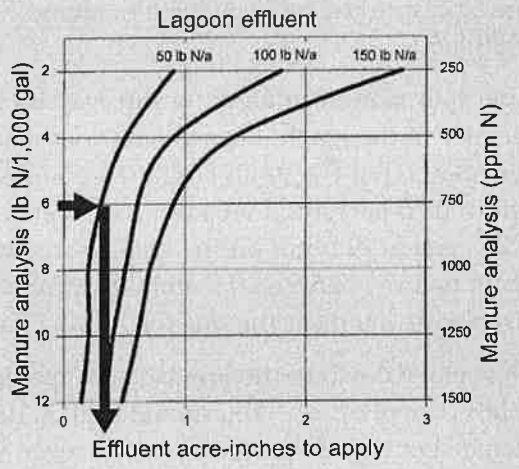


Table 2.—Approximate nitrogen removal by annual forage crops and suggested nitrogen application rates.

Crop	Average total yield (t/a)	N removal rate for average yield (lb N/a)	Suggested N application rate (lb N/t of forage*)
Silage corn			
75% moisture	30	180	5–7
dry matter basis	7	180	20–30
Annual ryegrass	5	100	15–25
Triticale	8	160	15–25
Oats	4	80	15–25
Sudan grass	5	250	50–60

*All rates are on dry matter basis unless noted otherwise.

Annual crops

You can follow a similar procedure to estimate the amount of manure needed for annual crops. For example:

1. From Table 2, find the total amount of N that is needed by the annual crop you will grow. We will use silage corn as an example. A 30-ton yield of silage corn requires 180 lb N/a.
2. Find the figure (Figures 4–6) that represents the type of manure you want to apply. Let's assume you'll apply separated solids, so use Figure 6.
3. Figure 6 contains three lines representing N application rates of 50, 100, and 150 lb N/a. Find the line that is closest to the rate you need to apply. You'll use the line for 150 lb/a since it is the closest to the rate you need to apply (180 lb/a).
4. Find your manure analysis for nitrogen on the left side of the graph. Let's assume your manure test shows that the solids contain 5 pounds of N/t or 0.25 percent N on a wet basis. Since 0.25 percent N is not on the graph, estimate a point halfway between 0.2 and 0.3. Move to the right until you meet the line for 150 lb N/a.
5. Now move down to the line labeled "manure solids to apply (t/a)." You should find 30 tons. Remember that 20 percent more nitrogen will be needed because no line exists for the 180 lb N/a required by the silage corn. The total estimated amount of solids required should be 35 t/a.

Note: If you know your own yield, you can figure your nitrogen need more accurately. To do so, multiply your tons per acre by the "suggested N application rate (lb N/t of forage)" in Table 2. The result is your N removal rate. Use the line in the appropriate figure that is closest to that rate.

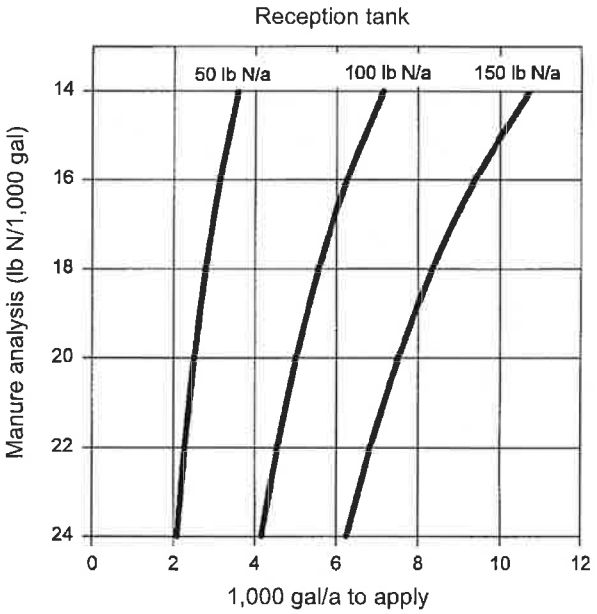


Figure 4.—Determining application rate for reception tank manure.

Special cases

The manure application rates in this publication are based on the assumption that manure already has been applied to fields for at least 4 consecutive years, not including the current year.

If your fields have received manure for less than 4 years, increase rates as shown in Table 3 if you use reception tank, separated solids, or dry stack material. Lagoon effluent provides sufficient available N for any situation when applied during the growing season.

Checking your application rate for silage corn

With silage corn, you can confirm that you applied sufficient manure by using the pre-sidedress soil nitrate test (PSNT). When the corn is 12 inches tall or at the five-leaf development stage, sample soil between rows to a depth of 12 inches. Have the sample analyzed for nitrate nitrogen (NO_3-N).

Compare the soil test results to Table 4. Apply the appropriate amount of lagoon effluent or fertilizer N to the growing crop based on the PSNT and Table 4.

It is important to handle samples properly. For more information, see *The Pre-sidedress Soil Nitrate Test (PSNT)*, EM 8650.

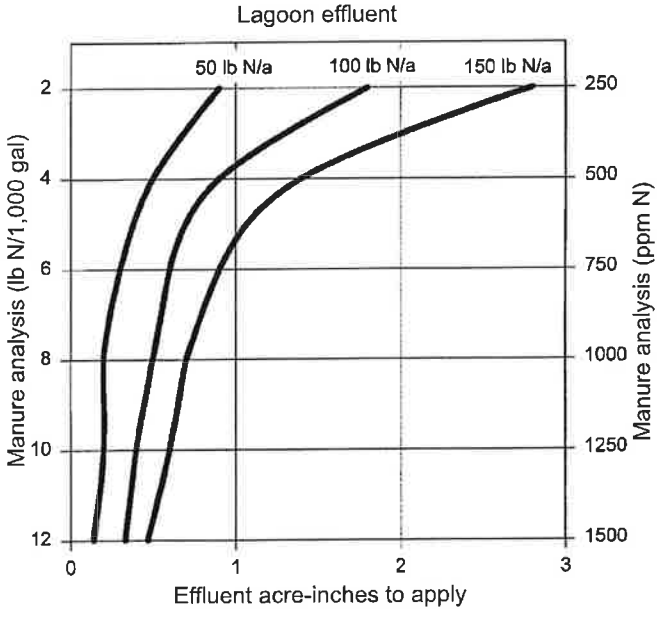


Figure 5.—Determining application rate for lagoon effluent.

Table 3.—Manure application rates based on number of years field has received manure.

If your field has received manure this many years:	Multiply suggested application rate by:
0	3.0
1	2.5
2	2.0
3	1.5
4 or more	Use suggested rates

Table 4.—Amount of nitrogen to apply for silage corn production based on the PSNT.

PSNT (ppm)	Nitrogen (lb/a)
0–10	100–150
10–20	50–100
20–25	0–50
above 25	0

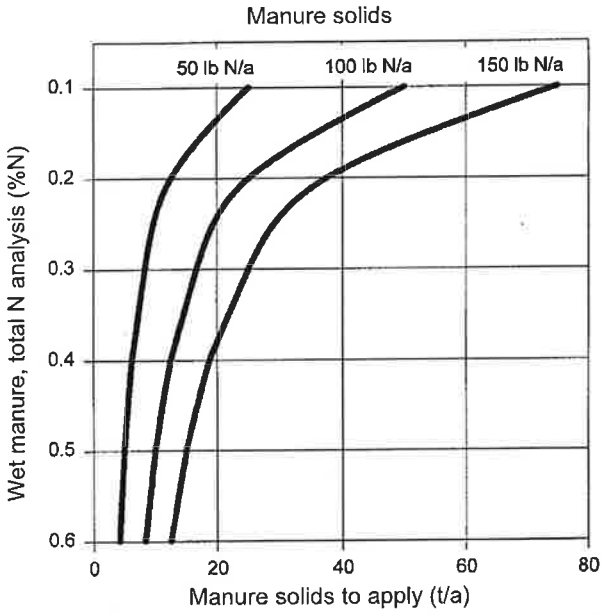


Figure 6.—Determining application rate for manure solids.

Testing your soil for P and K

Test your soil for phosphorus (P) and potassium (K) before applying manure. Table 5 provides interpretations of P and K soil tests.

If you've applied manure for more than 5 years, additions of P and K usually are not needed. For example, potassium usually is not deficient in soils where manure has been applied unless the applications were light and a high yield of grass hay was removed.

A manure application that meets crop nitrogen needs usually supplies sufficient amounts of P and K. Manure contains as much, if not more, K than N. For more information, see EM 8586, *Dairy Manure as a Fertilizer Source.*

In fact, fields that have received manure for a decade or more often have high soil test values for P and K. Fields with soil test K above 1,000 ppm can produce grass forage with a high K concentration. When grass forage with more than 3 percent K is fed to dry cows, serious illness or death may occur.

In some cases, a soil test shows excessive K, but N is needed. In this case, you have two options:

- Apply separated solids, which are lower in K than other forms of manure.
- If another area is available for manure application, apply manure there and buy N fertilizer for the area that has excess K.

Contact your county office of the OSU Extension Service for additional information.

New plantings

Little N is needed by new plantings. After N, phosphorus is the nutrient most likely to limit forage production. For new plantings or annual crops where manure has not been applied, apply 30 lb P_2O_5/a in a band-placed starter fertilizer. For more information, see FG 63, *Pastures Fertilizer Guide.*

Table 5.—Interpretation of soil tests for P and K.

	Nutrient	
Soil status	Phosphorus (P)	Potassium (K)
	(ppm)	
deficient	below 25	below 150
sufficient	25–50	150–500
high	50–75	500–1,000
excess	above 75	above 1,000

If P is deficient (see Table 5), also apply one of the following :

- 25 tons of separated solids
- 5,000 gallons of reception tank manure
- 5 wet tons of dry stack manure

End-of-season testing

The tables and figures in this publication provide only an estimate of manure application rates. An end-of-season soil test for nitrate nitrogen or stalk nitrate test for silage corn can aid in adjusting next season's manure application rates.

"Report card" soil testing

1. Sample soil to a depth of 12 inches as described for PSNT sampling. Sample from between rows, and avoid fertilizer bands. See EM 8650 for more information.
2. Prepare and handle the sample as described for PSNT sampling.
3. Have the sample analyzed for nitrate nitrogen (NO_3-N).

If soil NO_3-N test results are above 15 ppm, nitrogen probably was supplied in excess of crop needs. (To convert ppm to lb/a, multiply by 3.65.)

Corn stalk nitrate testing at harvest

1. Collect 10 mature corn plants by cutting the stalks just above the brace roots. Select representative plants away from edges of the field.
2. Cut an 8-inch section of stalk from the bottom of each harvested plant.
3. Remove the dried outer leaves from each 8-inch section.
4. Split each section of stalk lengthwise to aid in drying.
5. Place the split stalks together in a bag and send to a lab for nitrate nitrogen (NO_3-N) analysis.
6. Use Table 6 to interpret results.

Table 6.—Interpretation of corn stalk nitrate tests.

Stalk NO_3-N concentration at harvest	Interpretation
<3,500 ppm	N may have limited yield
3,500–5,500 ppm	N sufficient for optimum yield
>5,500 ppm	N supplied in excess of crop demand

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Hart, J. *A List of Analytical Laboratories Serving Oregon*, FG 74 (Oregon State University, Corvallis, revised 1996). No charge

Hart, J., G. Pirelli, L. Cannon, and S. Fransen. *Pastures Fertilizer Guide*, FG 63 (Oregon State University, Corvallis, 1993). No charge

Hart, J., M. Gangwer, M. Graham, and E.S. Marx. *Dairy Manure as a Fertilizer Source*, EM 8586 (Oregon State University, Corvallis, reprinted 1996). $1.00

Marx, E.S., N.W. Christensen, J. Hart, M. Gangwer, C.G. Cogger, and A.I. Bary. *The Pre-sidedress Soil Nitrate Test*, EM 8650 (Oregon State University, Corvallis, 1996). $1.00

Other publications

Marx, E. *Evaluation of Soil and Plant Analyses as Components of a Nitrogen Monitoring Program for Silage Corn* (Master's thesis, Oregon State University, 1995).

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