Appendix 1. Lagoon Sludge Survey Form Revised August 2008

NC State University A&T State University COOPERATIVE EXTENSION
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A. Farm Permit or DWQ Identification Number Richard Konger

B. Lagoon Identification 1

C. Person(s) Taking Measurements _____

D. Date of Measurement #########

E. Methods/Devices Used for Measurement of:

a. Distance from the lagoon liquid surface to the top of the sludge layer.
sonar

b. Distance from the lagoon liquid surface to the bottom (soil) of the lagoon.
sonar

c. Thickness of the sludge layer if making a direct measurement with "core sampler".
n/a

F. Lagoon Surface Area (using dimensions at inside top of bank): 3.4 (acres)
(Draw a sketch of the lagoon on a separate sheet, list dimensions, and calculate surface area. **The lagoon may have been built different than designed, so measurements should be made.)**

G. Estimate number of sampling points:

a. Less than 1.33 acres: Use 8 points

b. If more than 1.33 ac. _____ acres x 6 = _____, with maximum of 24.

(Using sketch and dimensions, develop a uniform grid that has the same number of intersections as the estimated number of sampling points needed. Number the intersection points on the lagoon grid so that data recorded at each can be easily matched.)

H. Conduct sludge survey and record data on "Sludge Survey Data Sheet" (Appendix 2). **Also, at the location of the pump intake, take measurements of distance from liquid surface to top of sludge layer and record it on the Data Sheet (last row); this must be at least 2.5 ft. when irrigating.**

I. At the time of the survey, also measure the distance from the Maximum Liquid Level to the Present Liquid Level (measure at the lagoon gauge pole): 0.0

J. Determine the distance from the top of bank to the Maximum Liquid Level (use lagoon management plan or other lagoon records) 1.6

K. Determine the distance from the Maximum Liquid to the Minimum Liquid level: (use lagoon management plan or other lagoon records) 0.0

L. Calculate the distance from the present liquid surface level to the Minimum Liquid Level (**Item K Minus Item I**, assuming the present liquid level is below the Maximum Liquid Level) 0.0

M. Record from the Sludge Survey Data Sheet the distance from the present liquid surface level to the lagoon bottom (average for all the measurement points) 8.7

N. Record from the Sludge Survey Data Sheet the distance from the present liquid surface level to the top of the sludge layer (average for all the measurement points): 4.1

O. Record from the Sludge Survey Data Sheet the average thickness of the sludge layer: 4.5

P. Calculate the thickness of the existing Liquid Treatment Zone (**Item N minus Item L**): 4.1

Q. **If Item O is greater than Item P, proceed to the Worksheet for Sludge Volume and Treatment Volume. If Item O is equal to or less than Item P, you do not have to determine volumes.**

Completed by: Eve H. Honeycutt Date: 12/19/2019
Print Name /Signature

Appendix 2. Sludge Survey Data Sheet* Revised August 2008

Lagoon Identification_____ 1

Completed by: _____ Eve H. Honeycutt _____ Date: ____ 12/19/2019

Print Name Signature

(A) Grid Point No.	(B) Distance from liquid surface to top of sludge			(C) Distance from liquid surface to lagoon bottom (soil)			(C)-(B) Thickness of sludge layer		
	Ft.	& in.	Ft. (tenths)	Ft.	& in.	Ft. (tenths)	Ft.	& in.	Ft. (tenths)
1			4.4			9.1			4.7
2			4.5			9.1			4.6
3			3.3			9.1			5.8
4			4.5			9.1			4.6
5			4.6			9.1			4.5
6			4.7			9.1			4.4
7			4.3			9.1			4.8
8			3.5			9.1			5.6
9			4.2			9.1			4.9
10			4.2			9.1			4.9
11			3.7			9.1			5.4
12			4.5			9.1			4.6
13			4.6			9.1			4.5
14			4.7			9.1			4.4
15			4.8			9.1			4.3
16			4.7			9.1			4.4
17			4.4			9.1			4.7
18			3.9			9.1			5.2
19			4.9			9.1			4.2
20			4.6			9.1			4.5
21			5.0			9.0			
22			0.0			0.0			0.0
23			0.0			0.0			0.0
24			0.0			0.0			0.0
Number of points with readings			21.0	X	X	21.0	X	X	21.0
Average of points	X	X	4.1428571	X	X	8.6666667	X	X	4.523809524
At pump intake			5.0	X	X	X	X	X	X

*All Grid Points and corresponding sludge layer thicknesses must be shown on a sketch attached to this Sludge Survey Data Sheet.

Appendix 3. Worksheet for sludge volume and treatment volume Revised August 2008

The average thickness of the sludge layer and the thickness of the existing liquid (sludge-free) treatment zone are determined from the information on the Lagoon Sludge Survey Form (Items O and P, respectively). In this example, the average sludge layer thickness is 2.5 feet and the existing liquid treatment zone is 3.5 feet. **If the lagoon has a designed sludge storage volume, see notes at end of the worksheet.** The dimensions of the lagoon as measured and the side slope are needed for calculations of sludge volume and of total treatment volume. If the lagoon is a standard geometric shape, the sludge volume and the treatment volume in the lagoon can be estimated by using standard equations. For approximate volumes of rectangular lagoons with constant side slope, calculate length and width at the midpoint of the layer, and multiply by layer thickness to calculate layer volume, as shown in the example. For irregular shapes, convert the total surface area to a square or rectangular shape. For exact volumes for lagoons with constant side slope, the "Prismoidal Equations" may be used.

	Example	Your Lagoon
1. Average sludge Layer Thickness (T)	2.5 ft.	4.5 ft.
2. Depth of the lagoon from top of bank to bottom soil surface (D)	11 ft.	10.3 ft.
3. Slope = Horizontal/ vertical side slope (S)	3	1.5
4. Length at the top of inside bank (L)	457 ft.	1004.0 ft.
5. Width at top inside slope (W)	229 ft.	147.0 ft.
6. Length at midpoint of sludge layer $L_m = L-2S(D-(T/2))$	398.5 ft.	980.0 ft.
7. Width at midpoint of sludge layer $W_m = W-2S(D-(T/2))$	170.5 ft.	123.0 ft.
8. Volume of sludge (Vs) $Vs=L_m W_m T$	169,860 ft^3	545,229 ft^3
9. Volume in gallons: $Vs_g=V*7.5$ gal./ft^3.	1,273,950 gal.	4,089,215 gal.
10. Thickness of existing liquid tmt. zone (Y)	3.5 ft	4.1 ft
11. Thickness of total treatment zone (Z) Z= T+Y	6 ft	8.7 ft
12. Length at midpoint of total tmt. zone $L_z = L-2(S)(D-(Z/2)$	409 ft.	986.2 ft.
13. Width at midpoint of total tmt. Zone $W_z = W-2(S)(D-(Z/2)$	181 ft.	129.2 ft.
14. Volume of total treatment zone (Vz) $Vz = L_z W_z Z$	444,174 ft^3	1,104,281 ft^3
15. Ratio (R) of sludge layer volume to total Treatment Volume R = Vs/Vz	0.38	0.49

If the ratio R exceeds 0.50, than a sludge Plan of Action may be required. Check with DWQ for information on filing the Plan of Action.

Note: If the lagoon has a designed sludge storage volume (DSSV), subtract that volume from both the volume of sludge (Vs) (Item 8) and from the volume of total treatment zone (Vz) (Item 14), and take the ratio.
Then, R = (Vs-DSSV) / (Vz - DSSV)
Example: If DSSV = 85,000 ft^3, then R = (169,860 - 85,000) / (447,174 - 85,000) = 84,860 / 362,174 = 0.24.

16. Design sludge storage volume (DSSV)	85,000	
17. Ratio (R) of sludge layer volume to treatment volume adjusted for designed sludge storage volume	0.24	0.49

Appendix 1. Lagoon Sludge Survey Form Revised August 2008

NC State University A&T State University COOPERATIVE EXTENSION
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A. Farm Permit or DWQ Identification Number: Richard Konger

B. Lagoon Identification: 2

C. Person(s) Taking Measurements: Eve Honeycutt

D. Date of Measurement: ########

E. Methods/Devices Used for Measurement of:

a. Distance from the lagoon liquid surface to the top of the sludge layer.
sonar boat

b. Distance from the lagoon liquid surface to the bottom (soil) of the lagoon.
calculated

c. Thickness of the sludge layer if making a direct measurement with "core sampler".
n/a

F. Lagoon Surface Area (using dimensions at inside top of bank): 2.8 (acres)
(Draw a sketch of the lagoon on a separate sheet, list dimensions, and calculate surface area. **The lagoon may have been built different than designed, so measurements should be made.)**

G. Estimate number of sampling points:

a. Less than 1.33 acres: Use 8 points

b. If more than 1.33 ac. _____ acres x 6 = _____, with maximum of 24.

(Using sketch and dimensions, develop a uniform grid that has the same number of intersections as the estimated number of sampling points needed. Number the intersection points on the lagoon grid so that data recorded at each can be easily matched.)

H. Conduct sludge survey and record data on "Sludge Survey Data Sheet" (Appendix 2). **Also, at the location of the pump intake, take measurements of distance from liquid surface to top of sludge layer and record it on the Data Sheet (last row); this must be at least 2.5 ft. when irrigating.**

I. At the time of the survey, also measure the distance from the Maximum Liquid Level to the Present Liquid Level (measure at the lagoon gauge pole): 1.4

J. Determine the distance from the top of bank to the Maximum Liquid Level (use lagoon management plan or other lagoon records) 1.6

K. Determine the distance from the Maximum Liquid to the Minimum Liquid level: (use lagoon management plan or other lagoon records) 1.9

L. Calculate the distance from the present liquid surface level to the Minimum Liquid Level (**Item K Minus Item I**, assuming the present liquid level is below the Maximum Liquid Level) 0.5

M. Record from the Sludge Survey Data Sheet the distance from the present liquid surface level to the lagoon bottom (average for all the measurement points) 7.0

N. Record from the Sludge Survey Data Sheet the distance from the present liquid surface level to the top of the sludge layer (average for all the measurement points): 4.0

O. Record from the Sludge Survey Data Sheet the average thickness of the sludge layer: 3.0

P. Calculate the thickness of the existing Liquid Treatment Zone (**Item N minus Item L**): 3.5

Q. **If Item O is greater than Item P, proceed to the Worksheet for Sludge Volume and Treatment Volume. If Item O is equal to or less than Item P, you do not have to determine volumes.**

Completed by: Eve H. Honeycutt Date: 12/19/2019
Print Name /Signature

Appendix 2. Sludge Survey Data Sheet* Revised August 2008

Lagoon Identification_____ 1

Completed by: _____ Eve H. Honeycutt _____ Date: _____ 12/19/2019

Print Name Signature

(A) Grid Point No.	(B) Distance from liquid surface to top of sludge			(C) Distance from liquid surface to lagoon bottom (soil)			(C)-(B) Thickness of sludge layer		
	Ft.	& in.	Ft. (tenths)	Ft.	& in.	Ft. (tenths)	Ft.	& in.	Ft. (tenths)
1			3.2			7.0			3.8
2			3.5			7.0			3.5
3			3.2			7.0			3.8
4			3.4			7.0			3.6
5			3.8			7.0			3.2
6			4.3			7.0			2.7
7			4.4			7.0			2.6
8			4.6			7.0			2.4
9			4.6			7.0			2.4
10			4.5			7.0			2.5
11			4.6			7.0			2.4
12			4.2			7.0			2.8
13			0.0			0.0			0.0
14			0.0			0.0			0.0
15			0.0			0.0			0.0
16			0.0			0.0			0.0
17			0.0			0.0			0.0
18			0.0			0.0			0.0
19			0.0			0.0			0.0
20			0.0			0.0			0.0
21			0.0			0.0			0.0
22			0.0			0.0			0.0
23			0.0			0.0			0.0
24			0.0			0.0			0.0
Number of points with readings			12.0	X	X	12.0	X	X	12.0
Average of points	X	X	4.025	X	X	7	X	X	2.975
At pump intake			5.0	X	X	X	X	X	X

*All Grid Points and corresponding sludge layer thicknesses must be shown on a sketch attached to this Sludge Survey Data Sheet.

Appendix 3. Worksheet for sludge volume and treatment volume Revised August 2008

The average thickness of the sludge layer and the thickness of the existing liquid (sludge-free) treatment zone are determined from the information on the Lagoon Sludge Survey Form (Items O and P, respectively). In this example, the average sludge layer thickness is 2.5 feet and the existing liquid treatment zone is 3.5 feet. **If the lagoon has a designed sludge storage volume, see notes at end of the worksheet.** The dimensions of the lagoon as measured and the side slope are needed for calculations of sludge volume and of total treatment volume. If the lagoon is a standard geometric shape, the sludge volume and the treatment volume in the lagoon can be estimated by using standard equations. For approximate volumes of rectangular lagoons with constant side slope, calculate length and width at the midpoint of the layer, and multiply by layer thickness to calculate layer volume, as shown in the example. For irregular shapes, convert the total surface area to a square or rectangular shape. For exact volumes for lagoons with constant side slope, the "Prismoidal Equations" may be used.

	Example	Your Lagoon
1. Average sludge Layer Thickness (T)	2.5 ft.	3.0 ft.
2. Depth of the lagoon from top of bank to bottom soil surface (D)	11 ft.	10.0 ft.
3. Slope = Horizontal/ vertical side slope (S)	3	2.0
4. Length at the top of inside bank (L)	457 ft.	610.0 ft.
5. Width at top inside slope (W)	229 ft.	200.0 ft.
6. Length at midpoint of sludge layer $L_m = L-2S(D-(T/2))$	398.5 ft.	576.0 ft.
7. Width at midpoint of sludge layer $W_m = W-2S(D-(T/2))$	170.5 ft.	166.0 ft.
8. Volume of sludge (Vs) $Vs=L_m W_m T$	169,860 ft^3	284,347 ft^3
9. Volume in gallons: $Vs_g=V*7.5$ gal./ft^3.	1,273,950 gal.	2,132,604 gal.
10. Thickness of existing liquid tmt. zone (Y)	3.5 ft	3.5 ft
11. Thickness of total treatment zone (Z) Z= T+Y	6 ft	6.5 ft
12. Length at midpoint of total tmt. zone $L_z = L-2(S)(D-(Z/2)$	409 ft.	583.0 ft.
13. Width at midpoint of total tmt. Zone $W_z = W-2(S)(D-(Z/2)$	181 ft.	173.0 ft.
14. Volume of total treatment zone (Vz) $Vz = L_z W_z Z$	444,174 ft^3	655,584 ft^3
15. Ratio (R) of sludge layer volume to total Treatment Volume R = Vs/Vz	0.38	0.43

If the ratio R exceeds 0.50, than a sludge Plan of Action may be required. Check with DWQ for information on filing the Plan of Action.

Note: If the lagoon has a designed sludge storage volume (DSSV), subtract that volume from both the volume of sludge (Vs) (Item 8) and from the volume of total treatment zone (Vz) (Item 14), and take the ratio.
Then, R = (Vs-DSSV) / (Vz - DSSV)
Example: If DSSV = 85,000 ft^3, then R = (169,860 - 85,000) / (447,174 - 85,000) = 84,860 / 362,174 = 0.24.

16. Design sludge storage volume (DSSV)	85,000	
17. Ratio (R) of sludge layer volume to treatment volume adjusted for designed sludge storage volume	0.24	0.43

Appendix 1. Lagoon Sludge Survey Form Revised August 2008

NC State University A&T State University COOPERATIVE EXTENSION
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A. Farm Permit or DWQ Identification Number: Richard Konger

B. Lagoon Identification: 3

C. Person(s) Taking Measurements: Eve Honeycutt

D. Date of Measurement: ########

E. Methods/Devices Used for Measurement of:

a. Distance from the lagoon liquid surface to the top of the sludge layer.
sonar boat

b. Distance from the lagoon liquid surface to the bottom (soil) of the lagoon.
calculated

c. Thickness of the sludge layer if making a direct measurement with "core sampler".
n/a

F. Lagoon Surface Area (using dimensions at inside top of bank): 3.3 (acres)
(Draw a sketch of the lagoon on a separate sheet, list dimensions, and calculate surface area. **The lagoon may have been built different than designed, so measurements should be made.)**

G. Estimate number of sampling points:

a. Less than 1.33 acres: Use 8 points

b. If more than 1.33 ac. _____ acres x 6 = _____, with maximum of 24.

(Using sketch and dimensions, develop a uniform grid that has the same number of intersections as the estimated number of sampling points needed. Number the intersection points on the lagoon grid so that data recorded at each can be easily matched.)

H. Conduct sludge survey and record data on "Sludge Survey Data Sheet" (Appendix 2). **Also, at the location of the pump intake, take measurements of distance from liquid surface to top of sludge layer and record it on the Data Sheet (last row); this must be at least 2.5 ft. when irrigating.**

I. At the time of the survey, also measure the distance from the Maximum Liquid Level to the Present Liquid Level (measure at the lagoon gauge pole): 2.1

J. Determine the distance from the top of bank to the Maximum Liquid Level (use lagoon management plan or other lagoon records) 1.6

K. Determine the distance from the Maximum Liquid to the Minimum Liquid level: (use lagoon management plan or other lagoon records) 1.9

L. Calculate the distance from the present liquid surface level to the Minimum Liquid Level (**Item K Minus Item I**, assuming the present liquid level is below the Maximum Liquid Level) -0.2

M. Record from the Sludge Survey Data Sheet the distance from the present liquid surface level to the lagoon bottom (average for all the measurement points) 7.4

N. Record from the Sludge Survey Data Sheet the distance from the present liquid surface level to the top of the sludge layer (average for all the measurement points): 4.2

O. Record from the Sludge Survey Data Sheet the average thickness of the sludge layer: 3.2

P. Calculate the thickness of the existing Liquid Treatment Zone (**Item N minus Item L**): 4.4

Q. **If Item O is greater than Item P, proceed to the Worksheet for Sludge Volume and Treatment Volume. If Item O is equal to or less than Item P, you do not have to determine volumes.**

Completed by: Eve H. Honeycutt (Print Name /Signature) Date: 12/19/2019

Appendix 2. Sludge Survey Data Sheet* Revised August 2008

Lagoon Identification_____ 1

Completed by: _____ Eve H. Honeycutt _____ Date: ____ 12/19/2019

Print Name Signature

(A) Grid Point No.	(B) Distance from liquid surface to top of sludge			(C) Distance from liquid surface to lagoon bottom (soil)			(C)-(B) Thickness of sludge layer		
	Ft.	& in.	Ft. (tenths)	Ft.	& in.	Ft. (tenths)	Ft.	& in.	Ft. (tenths)
1									0.0
2									0.0
3									0.0
4									0.0
5									0.0
6									0.0
7									0.0
8									0.0
9									0.0
10									0.0
11									0.0
12									0.0
13			0.0			0.0			0.0
14			0.0			0.0			0.0
15			0.0			0.0			0.0
16			0.0			0.0			0.0
17			0.0			0.0			0.0
18			0.0			0.0			0.0
19			0.0			0.0			0.0
20			0.0			0.0			0.0
21			0.0			0.0			0.0
22			0.0			0.0			0.0
23			0.0			0.0			0.0
24			0.0			0.0			0.0
Number of points with readings			sonar	X	X	sonar	X	X	sonar
Average of points	X	X	4.2	X	X	7.4	X	X	3.2
At pump intake			5.0	X	X	X	X	X	X

*All Grid Points and corresponding sludge layer thicknesses must be shown on a sketch attached to this Sludge Survey Data Sheet.

Appendix 3. Worksheet for sludge volume and treatment volume Revised August 2008

The average thickness of the sludge layer and the thickness of the existing liquid (sludge-free) treatment zone are determined from the information on the Lagoon Sludge Survey Form (Items O and P, respectively). In this example, the average sludge layer thickness is 2.5 feet and the existing liquid treatment zone is 3.5 feet. **If the lagoon has a designed sludge storage volume, see notes at end of the worksheet.** The dimensions of the lagoon as measured and the side slope are needed for calculations of sludge volume and of total treatment volume. If the lagoon is a standard geometric shape, the sludge volume and the treatment volume in the lagoon can be estimated by using standard equations. For approximate volumes of rectangular lagoons with constant side slope, calculate length and width at the midpoint of the layer, and multiply by layer thickness to calculate layer volume, as shown in the example. For irregular shapes, convert the total surface area to a square or rectangular shape. For exact volumes for lagoons with constant side slope, the "Prismoidal Equations" may be used.

	Example	Your Lagoon
1. Average sludge Layer Thickness (T)	2.5 ft.	3.2 ft.
2. Depth of the lagoon from top of bank to bottom soil surface (D)	11 ft.	11.1 ft.
3. Slope = Horizontal/ vertical side slope (S)	3	2.0
4. Length at the top of inside bank (L)	457 ft.	420.0 ft.
5. Width at top inside slope (W)	229 ft.	350.0 ft.
6. Length at midpoint of sludge layer $L_m = L-2S(D-(T/2))$	398.5 ft.	382.1 ft.
7. Width at midpoint of sludge layer $W_m = W-2S(D-(T/2))$	170.5 ft.	312.1 ft.
8. Volume of sludge (Vs) $Vs=L_m W_m T$	169,860 ft^3	381,566 ft^3
9. Volume in gallons: $Vs_g=V*7.5$ gal./ft^3.	1,273,950 gal.	2,861,749 gal.
10. Thickness of existing liquid tmt. zone (Y)	3.5 ft	4.4 ft
11. Thickness of total treatment zone (Z) Z= T+Y	6 ft	7.6 ft
12. Length at midpoint of total tmt. zone $L_z = L-2(S)(D-(Z/2)$	409 ft.	390.8 ft.
13. Width at midpoint of total tmt. Zone $W_z = W-2(S)(D-(Z/2)$	181 ft.	320.8 ft.
14. Volume of total treatment zone (Vz) $Vz = L_z W_z Z$	444,174 ft^3	950,510 ft^3
15. Ratio (R) of sludge layer volume to total Treatment Volume R = Vs/Vz	0.38	0.40

If the ratio R exceeds 0.50, than a sludge Plan of Action may be required. Check with DWQ for information on filing the Plan of Action.

Note: If the lagoon has a designed sludge storage volume (DSSV), subtract that volume from both the volume of sludge (Vs) (Item 8) and from the volume of total treatment zone (Vz) (Item 14), and take the ratio.
Then, R = (Vs-DSSV) / (Vz - DSSV)
Example: If DSSV = 85,000 ft^3, then R = (169,860 - 85,000) / (447,174 - 85,000) = 84,860 / 362,174 = 0.24.

16. Design sludge storage volume (DSSV)	85,000	
17. Ratio (R) of sludge layer volume to treatment volume adjusted for designed sludge storage volume	0.24	0.40