SOIL/MANURE MONITORING PROGRAM

at

BIG SKY RAMA COMPLEX

FINAL REPORT

Prepared for

THE SPIRIT CREEK WATERSHED MONITORING COMMITTEE

by

Head & Associates Ltd.
Nipawin, SK. S0E 1E0

February 2006

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

The Soil/Manure Monitoring Program is part of The Spirit Creek Watershed Monitoring Committee's mandate to monitor water, soil, and air in the vicinity of the Big Sky Farm Inc. three barn complex located in the Spirit Creek watershed near Rama, Saskatchewan.

The Program was designed to establish the initial nutrient levels and chemical characteristics of the soils of selected fields near each of the Big Sky barns. These soil factors were monitored for three crop years on fields that received manure and fields that received only commercial fertilizer as a means of assessing the relative risks of the nutrient sources to the Spirit Creek watershed.

Between 2001 and 2005 nitrogen levels in the Manure fields increased an average of about 85 lb/ac. While this represents a marked improvement in the productive potential of the fields, it also suggests that manure nitrogen rates in a three crop year rotation should not exceed 300 lb/ac and that the addition of nitrogen fertilizer to fields that have received manure should be done with the knowledge that nitrogen mineralization rates in manured fields can be greater than predicted by soil test results.

Nitrate levels increased in the Fertilizer fields by about 38 lb/ac between 2001 and 2005, suggesting factors other than manure may have contributed to the increase observed in the Manure fields.

Available phosphorus levels increased marginally in the Manure fields and decreased marginally in the Fertilizer fields. Soil potassium and micronutrient levels were not significantly affected by manure application.

In 2003 and 2005 crops produced with manure yielded more than those grown with commercial fertilizer. In 2004 three of the four Manure fields yielded less than the Fertilizer fields, likely due to frost damage on the manure plots.

Regular monitoring of soil conditions and flexibility in the application rates of both manure and fertilizer will allow hog manure to be used to the benefit of crop producers in the area with little or no risk to the Spirit Creek watershed.

ACKNOWLEDGEMENTS

The cooperation and assistance of the following individuals and organizations is gratefully acknowledged.

Mr. Don Walters and the Spirit Creek Watershed Monitoring Committee and particularly the Soils Subcommittee members Mr. Jim Davis, Mr. Don Olson, and Mr. Adam Kosar for guidance and field assistance during the project.

Farm cooperators Mr. Donald Dean, Mr. Alec Dutchak, Mr. Don Dutchak, Mr. Darryl Dutchak, Mr. Lorne Matsalla, and Mr. Randy Nieckar, for providing the land and modifying their farm management to facilitate the project.

Big Sky Farms Inc, and particularly Mr. Ernie Patrick for manure sampling, and modifying the manure application program on the test fields to suit the project.

Mr. Kim Stonehouse, East Central Research Foundation, for weigh wagon services.

Cargill Ltd, Armley, for grading grain samples.

Funding provided by Saskatchewan Agriculture and Food is gratefully acknowledged.

1.0 INTRODUCTION

The Soil/Manure Monitoring Program is part of The Spirit Creek Watershed Monitoring Committee's mandate to monitor water, soil, and air to determine if the Big Sky Farm Inc. hog operation poses any threat to the Spirit Creek watershed.

This report marks the end of the four year Program. It includes the 2005 field results and summarizes the information from all years. The reader is referred to the Annual Interim Reports for the detailed yearly results.

2.0 SCOPE OF THE PROGRAM

The Soil/Manure Monitoring Program was designed to monitor the effect that pig manure may have on the soils on which manure is used as a crop production input, and on the crops grown thereon.

The main activities were:

1. **The Soil Benchmark Program** – This Program collected soil nutrient level and chemical data on eight quarter sections near the three barn locations. These data established the soil conditions prior to manure application to the fields.
2. **Manure/Commercial Fertilizer Comparison** – This Program compared the use of manure and commercial fertilizer in crop production. The Program was carried out on 4 of the quarter sections on which soil benchmark sampling was done. The three crops immediately following manure application were monitored.
3. **Yearly Monitoring Program** – This Program tracked the nutrient levels in each of the four fields in the Manure/Commercial Fertilizer Program. The fields were sampled after harvest in 2003, 2004, and 2005.

3.0 THE SOIL BENCHMARK PROGRAM

The Soil Benchmark Program was designed to establish the characteristics of the soils on eight quarter sections prior to any manure being applied to the fields.

On each quarter section separate soil samples were collected from the upper slope, mid slope, and lower slope positions in the landscape. Soil cores were collected at ten sites in each slope position.

Each sample location was geo-referenced using Global Positioning Satellite (GPS) technology. The coordinates for each sample location are provided in Appendix A.

The soil cores extended to a depth of 48 inches into the ground and were each separated into four 12 inch layers. The depth layer samples from each of the 10 cores for the individual slope positions were combined so that for each slope position there were four individual soil samples, one from each soil depth layer.

Each soil depth layer sample was analyzed for various nutrient and chemical properties as outlined in Table 1.

Table 1. Soil analyses for each soil depth layer

Depth (in)	Analyses
0 - 12	Available N, P, K, S, Cu, Fe, Zn, Mn, B, Total P, Organic Matter (OM), Electrical Conductivity (EC)
12 – 24	Available N, S, Total P, EC
24 - 36	Available N, S, EC
36 - 48	Available N, S, EC

The results of Soil Benchmark Program (Appendix C) indicate that the fertility status of the soils of the area is relatively low. The initial available nitrate levels to a depth of 48 inches, if two unusually high lower slope readings are excluded, averaged only about 52 lb/ac. The initial available nitrate to 24 inches was only 33 lb/ac, a level considered very deficient by soil test guidelines.

The available phosphorus levels, if three unusually high lower slope readings are excluded, averaged only 30 lb/ac. This phosphorus level is considered deficient by soil

test standards and would generate a recommendation to apply from 30 to 40 lb/ac of phosphate.

The average available potassium level was about 528 lb/ac, a level considered sufficient by soil test guidelines. The available sulfur and micronutrient contents were all at levels considered sufficient for the annual crops produced in the region.

4.0 MANURE / COMMERCIAL FERTILIZER COMPARISON

This program was designed to compare crop production using manure as the nutrient source with using commercial fertilizer as the nutrient source. Yield and quality measurements were determined for the first three crops following manure application. Similar measurements were taken from the corresponding plot areas that received commercial fertilizer as the source of nutrients.

4.1 Test Fields

Four of the quarters (Fields 1, 2, 3 & 4) selected for benchmark sampling were used in this program. Fields 1 & 2 are near the Matsalla Finisher Barn, Field 3 is near the Korchinski Breeder Barn, and Field 4 is near the Main Road Nursery Barn.

Each quarter section was divided into two areas. One area received manure and the second area received commercial fertilizer (Appendix B). The benchmark sampling of these four quarters was modified so that the two plot areas on each quarter were sampled separately.

4.2 Manure Application

Manure was applied to the Program fields at the Breeder Barn (Field 3) and at the Nursery Barn (Field 4) in October of 2002. Fields 1 and 2 at the Finisher Barn received manure in the spring of 2003.

The manure was injected into the soil using a three point hitch mounted applicator equipped with rolling coulters that open furrows into which the manure is injected. The manure was pumped to the applicator through a combination of pipe and flexible drag hose.

Manure nutrient application rates for the four fields are provided in Tables 2, 4, 6, & 8.

4.3 Manure Sampling

Manure samples were taken during manure application to each of the fields. The samples were drawn from the pump that feeds manure to the applicator and from the applicator in the field. The quarter sections were divided into four quadrants prior to manure application. Manure was applied to each quadrant in turn. Two samples, one from the pump and one from the applicator, were taken while manure was being applied to each of the field quadrants. The samples were forwarded to EnviroTest Laboratories in Saskatoon for analysis.

The results of the manure analyses are provided in Appendix D.

4.4 Field 1 – Finisher Barn – NW 6-33-6-W2 Cooperator - Lorne Matsalla

The relatively high solids content of the manure resulted in the Manure plot on Field 1 receiving the highest rate of nutrients of the four test fields even though the manure application rate was similar to the other fields. The Manure plot received additional fertilizer applications depending on the soil samples taken after each crop.

The nutrient applications to the Fertilizer plot were managed according to the fertility program of the farm cooperator. The nutrients applied to the plots on Field 1 are listed in Table 2.

Field 1 was planted to barley in 2003, canola in 2004, and wheat in 2005. In each year the crop on the Manure plot looked better and yielded more than on the Fertilizer plot (Table 3). The yield differences were larger in the first two years than on any of the other three sites. This is likely a result of the larger amount of phosphorus applied to Field 1 than to the other fields. The higher phosphorus levels would allow the crop to better utilize the large amount of available nitrogen in the first year. Similarly, the good phosphorus fertility would enhance the maturity of the 2004 canola crop, thus preventing the severe frost damage that occurred on the other three fields.

Table 2. Nutrients applied to the Manure and Fertilizer plots on Field 1

Plot	Date	Source	Rate g/ac	Nutrient Rates (lb/ac)					
				NH_4-N	Total N	P	K	S	Solids
Manure	May/03	Manure	8300	339	448	141	157	50	6225
	May/04	Fertilizer		78	78	7		6	
	May/05	Fertilizer		76	76	13	8		
Total Applied				**493**	**602**	**161**	**165**	**56**	**6225**
Fertilizer	May/03	Fertilizer		80					
	May/04	Fertilizer		78		7		6	
	May/05	Fertilizer		76		13	8		
Total Applied				**234**		**20**	**8**	**6**	

The cereals grown on the Manure plot in 2003 and 2005 had higher protein contents than those produced on the Fertilizer plot, reflecting the higher nitrogen fertility provided by the manure.

Table 3. Crop yields and grades for Field 1

Year	Plot	Crop	Yield (bus/ac)	Grade	Bus Wt (lb)	Protein (%)
2003	Manure	Barley	82	1CW	50.3	13.8
	Fertilizer	Barley	52	1CW	53.7	13.2
2004	Manure	Canola	32	3CR		
	Fertilizer	Canola	22	2CR		
2005	Manure	Wheat	37	3CWRS	61.7	11.5
	Fertilizer	Wheat	33	3CWRS	61.7	11.0

4.5 Field 2 - Finisher Barn – SE 13-33-7-W2 Cooperator Randy Nieckar

The Manure plot in Field 2 received less manure nutrients than Field 1, but more than the other two fields. The Manure plot received additional fertilizer applications depending on

the soil samples taken after each crop. Nutrients were applied to the Fertilizer plot according to the fertility program of the farm cooperator. The nutrients applied to Field 2 are listed in Table 4.

Field 2 was planted to canola in 2003, wheat in 2004, and barley in 2005. This field did not show visual differences between the Manure and Fertilizer plots. The canola in 2003 and the barley in 2005 yielded significantly more on the Manure plot than the Fertilizer plot. In 2004, however, the wheat crop yielded more on the Fertilizer plot. This is likely because the crop on the Manure plot was less mature at the time of the August frosts and therefore more susceptible to damage. Although grain from both plots graded Feed, the grain from the Manure plot had a lower bushel weight suggesting it suffered more frost damage (Table 5).

Both the wheat and barley crops had higher protein on the Manure plot than on the Fertilizer plot reflecting the higher nitrogen fertility provided by the manure.

Table 4. Nutrients applied to the Manure and Fertilizer plots on Field 2

Plot	Date	Source	Rate g/ac	Nutrient Rates (lb/ac)					
				NH_4-N	Total N	P	K	S	Solids
Manure	May/03	Manure	8003	290	336	24	152	32	1760
	May/03	Fertilizer		16	16	2		2	
	May/04	Fertilizer		35	35	4	5		
	May/05	Fertilizer		74	74	9	8		
Total Applied				**415**	**461**	**39**	**165**	**34**	**1760**
Fertilizer	May/03	Fertilizer		83		17		15	
	May/04	Fertilizer		74		9	8		
	May/05	Fertilizer		74		9	8		
Total Applied				**231**		**35**	**16**	**15**	

Table 5. Crop yields and grades for Field 2

Year	Plot	Crop	Yield (bus/ac)	Grade	Bus Wt (lb)	Protein (%)
2003	Manure	Canola	32	1CR		
	Fertilizer	Canola	24	1CR		
2004	Manure	Wheat	29	C Feed	59.4	13.9
	Fertilizer	Wheat	44	C Feed	62.7	12.5
2005	Manure	Barley	52	Sample	47.2	13.0
	Fertilizer	Barley	46	2CW	44.3	12.1

4.6 Field 3 - Breeder Barn – SW 5-32-7-W2 Cooperators Alec & Don Dutchak

The Manure plot on Field 3, although receiving the highest rate of manure application, received the lowest rate of manure nutrients, due to the low solids content of the manure (Table 6). Additional fertilizer was applied to the Manure plot depending on the annual soil test recommendations. The Fertilizer plot was managed according to the fertility program of the cooperator.

Table 6. Nutrients applied to the Manure and Fertilizer plots on Field 3

Plot	Date	Source	Rate g/ac	Nutrient Rates (lb/ac)					
				NH_4-N	Total N	P	K	S	Solids
Manure	Oct/02	Manure	10,874	226	266	16	147	14	1332
	May/03	Fertilizer		10	10	18	4		
	May/04	Fertilizer		37	37	6			
	May/05	Fertilizer		70	70	9		10	
Total Applied				**343**	**383**	**49**	**151**	**24**	**1332**
Fertilizer	May/03	Fertilizer		80		18	4		
	May/04	Fertilizer		102		6			
	May/05	Fertilizer		70		9		10	
Total Applied				**252**		**33**	**4**	**10**	

Field 3 was planted to wheat in 2003, barley in 2004, and canola in 2005. Field 3 showed a yield response pattern similar to Field 2 in that only in 2004 did the Fertilizer plot yield more than the Manure plot. This again is attributed to the later maturity caused by the high fertility of the Manure plot making the barley more susceptible to frost damage. Bushel weights and grain grades also point to frost damage on the Manure plot (Table 7).

Table 7. Crop yield and quality for the Manure and Fertilizer Plots on Field 3

Year	Plot	Crop	Yield (bus/ac)	Grade	Bus Wt (lb)	Protein (%)
2003	Manure	Wheat	50	1CWRS	63.1	15.3
	Fertilizer	Wheat	45	1CWRS	64.6	14.0
2004	Manure	Barley	62	Sample	41.8	12.8
	Fertilizer	Barley	77	2CW	47.1	12.2
2005	Manure	Canola	43	1CR		
	Fertilizer	Canola	36	1CR		

4.7 Field 4 - Nursery Barn – SE 2-32-8-W2 Cooperator Donald Dean

The manure application rate on Field 4 was similar to Field 2, resulting in an intermediate level of nutrients (Table 8). Additional nutrients were added to the Manure plot each year on the basis of soil test recommendations. The Fertilizer plot was managed according to the fertility program of the cooperator.

Field 4 was planted to wheat in 2003, canola in 2004, and wheat in 2005. Both the cereal crops performed better on the Manure plot than on the Fertilizer plot. However, the canola in 2004 was severely injured by the August frosts and there was no difference in yield between the two plots. The cereals produced on the Manure plot had higher protein content than on the Fertilizer plots reflecting the higher nitrogen fertility provided by the hog manure (Table 9).

Table 8. Nutrients applied to the Manure and Fertilizer plots on Field 4

Plot	Date	Source	Rate g/ac	Nutrient Rates (lb/ac)					
				NH_4-N	Total N	P	K	S	Solids
Manure	Oct/02	Manure	8,543	260	305	19	188	21	1623
	May/03	Fertilizer		5	5	10			
	May/04	Fertilizer		40	40	11		15	
	May/05	Fertilizer		70	70	11			
Total Applied				**375**	**420**	**51**	**188**	**36**	**1623**
Fertilizer	May/03	Fertilizer		65		10			
	May/04	Fertilizer		40		11		15	
	May/05	Fertilizer		70		11			
Total Applied				**175**		**32**		**15**	

Table 9. Crop yield and quality for the Manure and Fertilizer Plots on Field 4

Year	Plot	Crop	Yield (bus/ac)	Grade	Bus Wt (lb)	Protein (%)
2003	Manure	Wheat	43	2CWRS	60.6	14.9
	Fertilizer	Wheat	41	2CWRS	60.4	14.3
2004	Manure	Canola	22	1CR		
	Fertilizer	Canola	22	2CR		
2005	Manure	Wheat	53	3CWRS	61.9	13.6
	Fertilizer	Wheat	47	3CWRS	61.9	12.4

4.8 Summary

Except for 2004 when early frost affected crop yields, the Manure plots produced higher yields than the Fertilizer plots. This reflects the significantly higher nutrient status of the

Manure plots. On average the Manure plots received about 244 lb/ac more nitrogen than the Fertilizer plots. They also received on average about 45 lb/ac more phosphorus.

In total the Manure plots produced 2378 lb or 9% more grain than the Fertilizer plots. If the 2004 yields are not included, the Manure plots produced 3498 lb or 20% more than the Fertilizer plots. The increased yield potential of the Manure plots is a result of the high fertility status provided by the nutrients in the hog manure, particularly the nitrogen.

5.0 YEARLY MONITORING PROGRAM

This Program monitored the nutrient levels in each of the four fields in the Manure/Commercial Fertilizer Comparison Program. Each year after harvest soil samples were collected from the same core sites as were used for the initial benchmark samples. Sampling was done to a 24 inch depth after the 2003 and 2004 crop to provide fertilizer requirements for the succeeding crops. In 2005, the final year of the study, sampling was done to the original 48 inch depth to determine any changes in the nutrient status of the field plots.

Wet soil conditions in the fall of 2005 prevented sampling of a number of the Lower Slope sampling sites. These included Sample Site 6 in the Fertilizer Plot on Field 2; Sample Sites 1 and 5 in the Manure Plot on Field 3; Sample Sites 1 and 4 in the Fertilizer Plot on Field 3; Sample Sites 2, 4, and 6 in the Manure Plot on Field 4; and, Sample Sites 2 & 3 in the Fertilizer Plot on Field 4.

The results of the soil analyses for all four years are provided in Appendix C.

5.1 Nitrate

Soil nitrate levels increased in all the Manure plots between 2001 and 2005. The increases occurred in all three slope positions and averaged 85 lb/ac (Table 10). This increase in soil nitrate may be due to more than just the application of manure to the plots. Additional nitrogen fertilizer was applied to the plots for the 2004 and 2005 crops. The fertilizer application rates in 2004 and 2005 were based on soil test recommendations (Table 11). Nitrogen fertility recommendations generated from soil test data are based on the nitrate

Table 10. Average increase in soil nitrate levels (lb/ac) to a 48 inch depth in the Manure and Fertilizer plots between 2001 and 2005

Slope Position	**Manure Plots Nitrate Levels (lb/ac)**			**Fertilizer Plots Nitrate Levels (lb/ac)**		
	2001	2005	Increase	2001	2005	Increase
Upper	55	151	96	42	74	32
Mid	35	111	76	39	78	39
Lower	123	207	84	38	83	45
Average	71	156	85	40	78	38

levels in the soil at the time of sampling and an estimate of the amount of nitrate that will be mineralized in the soil during the growing season. The mineralization estimate is based on soil type and soil climatic zone, but may underestimate mineralization in soils that have received hog manure. Consequently, the nitrogen fertilizer application rates for the 2004 and 2005 crop may have been higher than necessary and contributed to the increase in soil nitrate at the end of the project.

Table 11. Nitrogen recommended and applied to the Manure plots in 2004 and 2005

FIELD	**YEAR**	**CROP**	**YIELD GOAL (bus/ac)**	**RECOMM'D N RATE (lb/ac)**	**APPLIED N RATE (lb/ac)**
1	2004	Canola	40	45	78
	2005	Wheat	50	90	76
2	2004	Wheat	50	35	35
	2005	Barley	60	75	74
3	2004	Barley	60	35	37
	2005	Canola	40	90	70
4	2004	Canola	40	35	40
	2005	Wheat	50	75	70

The soil nitrate levels also increased in the Fertilizer plots by an average of 38 lb/ac even though nitrogen fertilizer rates were not excessive during the study period. The observed increase was likely due to mineralization of soil nitrogen. In 2005 good soil moisture in August and relatively warm weather in September would have enhanced nitrogen mineralization. Crop uptake during the same time period would have been relatively low, allowing much of the additional nitrate to accumulate in the soil profile. This process would have occurred in the Manure plots as well and contributed to the increased levels of soil nitrate observed in those plots.

The increase in nitrate levels in the fields occurred in all soil layers to a depth of 48 inches (Table 12). The lowest increase was in the 0-12 inch layer and the highest in the 24-36 inch layer for both the Manure and Fertilizer plots. The unusually high precipitation in 2005 exceeded crop water use resulting in a net downward movement of water in the soil profile and a corresponding movement of nitrate in the soil profile.

Table 12. Average increase in soil nitrate levels (lb/ac) in the soil layers in the Manure and Fertilizer plots between 2001 and 2005

Soil Layer (inches)	**Manure Plots Nitrate Levels (lb/ac)**			**Fertilizer Plots Nitrate Levels (lb/ac)**		
	2001	2005	Increase	2001	2005	Increase
0-12	37	45	8	20	27	7
12-24	15	35	20	6	16	10
24-36	9	41	32	6	17	11
36-48	11	36	25	8	18	10
Total Average Increase			85	Total Average Increase		38

5.2 Phosphorus

The relatively low phosphorus content of the manure resulted in only modest applications of phosphorus to the Manure plots in Fields 2, 3, & 4 (Tables 4, 6, & 8). The average amount of phosphorus applied to these fields over the time between 2001 and 2005 was

about 46 lb/ac. Field 1 however, received manure containing a significant amount of solids that resulted in a phosphorus application rate of about 141 lb/ac in the manure plus 20 lb/ac from commercial fertilizer additions between 2001 and 2005 (Table 2). The higher phosphorus fertility likely accounts for the higher and more consistent yield increases observed in the Manure plot on Field 1 than on the other Fields.

The Fertilizer plots did not receive enough phosphorus between 2001 and 2005 to maintain available phosphorus levels in the soil (Table 12). On average the available phosphorus levels in the Fertilizer plots decreased by 6 lb/ac.

On average, however, available phosphorus in the Manure plots increased only slightly, with most of the increase occurring in the Lower Slope position (Table 13). The total phosphorus in the top 24 inches of soil actually decreased (Table 14) indicating the relatively low phosphorus fertility status of the soils.

Table 13. Average increase (decrease) in soil available phosphorus levels (lb/ac) in the Manure and Fertilizer plots between 2001 and 2005

Slope Position	**Manure Plots Available Phosphorus Levels (lb/ac)**			**Fertilizer Plots Available Phosphorus Levels (lb/ac)**		
	2001	2005	Increase	2001	2005	Increase
Upper	19	23	4	18	14	(4)
Mid	20	27	7	25	18	(7)
Lower	36	61	25	85	78	(7)
Average	25	37	12	43	37	(6)

The total phosphorus in the soil decreased between 2001 and 2005 in both the Manure and the Fertilizer plots. This decrease was consistent across all fields and plots, but the amount of the decrease was less in the Manure plots than the Fertilizer plots (Table 14).

These data illustrate the low phosphorus fertility status of soils in the area and indicate that additional phosphorus received from manure applications should gradually improve soil phosphorus fertility.

Table 14. Average increase (decrease) in total soil phosphorus levels (lb/ac) in the Manure and Fertilizer plots between 2001 and 2005

Soil Layer (inches)	**Manure Plots Total Phosphorus Levels (lb/ac)**			**Fertilizer Plots Total Phosphorus Levels (lb/ac)**		
	2001	2005	Increase	2001	2005	Increase
0-12	523	517	(6)	575	519	(56)
12-24	487	427	(60)	513	486	(27)
Total Average Increase			(66)	Total Average Increase		(83)

5.3 Potassium

The Manure plots received an average of 167 lb/ac of potassium from the manure and commercial fertilizer applications between 2001 and 2005. The levels of available potassium increased in the Manure plots by an average of 318 lb/ac. However, the Fertilizer plots also showed increases in available potassium although only receiving an average of 9 lb/ac of potassium, an amount that would have no significant impact on total soil available potassium.

It must be assumed therefore that a significant portion of the increase in soil available potassium observed in the Manure plots is due to factors other than the addition of potassium in the manure. These factors include mineralization of potassium due to the good moisture conditions in 2005, and variability in soil sampling.

5.4 Sulfur

Sulfur levels have changed in the soils in both the Manure and the Fertilizer plots between 2001 and 2005. In the Manure plots the sulfur levels have increased an average of about 846 lb/ac. In the Fertilizer plots the sulfur levels have decreased an average of about 1850 lb/ac.

Neither of these changes can be attributed to manure or fertilizer application nor to crop uptake. The sulfur in the manure did not exceed 60 lb/ac on any of the plots so does not

account for all of the increase in sulfur. Crop uptake on the Fertilizer plots does not account for the decrease in sulfur on those plots.

The observed changes in soil sulfur levels are likely due to differences in soil moisture and soil moisture movement, and perhaps most significantly, with variability in soil sampling procedures. The soils in the study area have sulfur levels of several thousand lb/ac. At these levels small differences in soil characteristics or sampling procedures can have large effects on soil analytical results.

5.5 Micronutrients

The levels of available micronutrients in the Manure plots increased between 2001 and 2005 (Table 15). However, the amount of increase was many times greater than the amount of micronutrients applied in the manure. On average the Manure plots received 0.28, 4.6, 0.5, and 1.7 lb/ac of copper, iron, manganese, and zinc, respectively. The levels of available micronutrients increased by 1.5, 54, 11.2, and 7.2 lb/ac for copper, iron, manganese, and zinc, respectively. The increase in the observed micronutrient levels must be due to factors such as soil and sampling variability rather than manure application.

The available micronutrient levels also increased in the Fertilizer plots, although no micronutrient fertilizers were applied during study, further suggesting that soil and sampling factors were affecting the analytical results.

These results suggest that the micronutrient levels in the hog manure do not pose a risk to the productivity of the soils in the region or to the Spirit Creek watershed.

Table 15. Average micronutrient levels (lb/ac) in the Manure and Fertilizer plots in 2001 and 2005

	Manure Plots Micronutrient Levels (lb/ac)					**Fertilizer Plots Micronutrient Levels (lb/ac)**				
	Cu	**Fe**	**Mn**	**Zn**	**B**	**Cu**	**Fe**	**Mn**	**Zn**	**B**
2001	2.2	71	11.8	2.7	1.6	2.6	92	14.1	3.1	1.8
2005	3.7	125	23.0	9.9	4.9	3.7	134	27.7	8.5	4.3

6.0 MANURE APPLICATION HISTORY

Manure produced by the Big Sky barns at Rama was first applied to farmland in the spring of 2002. Since that time about 9400 acres around the facilities have received manure.

A summary of the land locations and dates of application is provided in Appendix D. It is based on information supplied by Big Sky Farms Inc and covers the period from the spring of 2002 to the fall of 2005.

The same information is provided in the Spirit Creek GIS Data Base developed by Prairie Mapping Services. A hard copy map is supplied inside the back cover of this report. The digital file can be viewed with GIS software that recognizes .dwf files.

7.0 SUMMARY AND CONCLUSIONS

The results the Manure/Commercial Fertilizer Comparison study indicate that hog manure as applied to the trial fields will produce as high or higher yields than commercial fertilizer applied at the rates used in this study. Overall, the Manure plots produced about 9% more grain than the Fertilizer plots. If the results from the frost damaged plots in 2004 are excluded, the difference in grain production increases to about 20%. The increased production is due primarily to the improved nitrogen fertility provided by the manure. Properly used, hog manure will increase the productive potential of the soils in the Rama area.

The results of the Soil Benchmark and Yearly Monitoring programs indicate that the level of soil nitrate has increased in the Manure plots during the course of the study. The fact that soil nitrate levels have also increased in the Fertilizer plots indicate that factors other than manure application are contributing to the increased soil nitrate in the Manure plots. These factors include nitrogen mineralization rates and the application of nitrogen fertilizer to the manure plots.

Although the soil nitrate levels have increased as a result of manure application, the increases need to be viewed with some perspective. The soil nitrate levels in the top 48 inches of soil increased an average of 85 lb/acre in the manure plots and 38 lb/acre in the commercial fertilizer plots (Table 12), a difference of only 47 lb/acre. It should be noted

that this increase occurred over a four foot soil profile while most routine soil sampling and nutrient guidelines are designed for a depth of only two feet.

Although there are no formal regulations in Saskatchewan regarding soil nitrate levels in manure management, the Manitoba regulations allow up to 140 lb/acre of nitrate in the top **two feet** of soil.

In the top two feet of soil in the manure fields there is an average of only 80 lb/acre, significantly less than the level considered critical in Manitoba.

Soil test summaries produced by the former Enviro-Test Laboratories in Saskatoon indicate that nitrate levels in summer fallow fields in the Black Soil Zone in Saskatchewan average from 70 to over 100 lb/acre in the top two feet. The manure fields therefore have nitrogen fertility levels comparable to those routinely obtained by the practice of summer fallow.

At this point it is safe to say that manure application to the test fields has improved the fertility status of the soils while maintaining nutrient levels well within accepted environmental guidelines. Proposed monitoring of these fields over the next 6 years will determine if changes to manure management practices will be necessary to maintain the fertility levels without risk to the environment of the Spirit Creek watershed.

It was observed in this study that standard nitrogen soil test recommendations likely over estimate the amount of nitrogen fertilizer required on fields that have received manure. Consequently it is recommended that nitrogen fertilizer applications to manure fields be done at rates significantly below recommended rates until adequate application guidelines are in place.

The results of the Soil/Manure Monitoring Program suggest that manure nitrogen application rates in a three crop year manure rotation should not exceed 300 lb/ac. Regular monitoring of soil conditions and flexibility in the application rates of both manure and fertilizer will allow hog manure to be used to the benefit of crop producers with little or no risk to the Spirit Creek watershed.

8.0 CLOSURE

This report covers the activities completed during the final year of the Soil/Manure Monitoring Program and summarizes the project results. Please contact the undersigned at your convenience if there are any questions, or if we can assist in any way.

Yours truly,

HEAD & ASSOCIATES LTD.

W. Keith Head, MSc, PAg, CAC
Senior Agrologist

APPENDICES

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES

Field 1 Fertilizer Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8077871	-102.8545450	47	1686	10/13/2001
2	51.8075284	-102.8536721	47	1687	10/13/2001
3	51.8077884	-102.8520707	47	1685	10/13/2001
4	51.8078920	-102.8497359	47	1686	10/13/2001
5	51.8077451	-102.8485560	47	1688	10/13/2001
6	51.8076184	-102.8473341	47	1685	10/13/2001

Field 1 Fertilizer Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8075955	-102.8463918	47	1682	10/13/2001
2	51.8076429	-102.8479011	47	1683	10/13/2001
3	51.8077201	-102.8497128	47	1684	10/13/2001
4	51.8076123	-102.8521205	47	1684	10/13/2001
5	51.8076049	-102.8532967	47	1686	10/13/2001
6	51.8079433	-102.8549449	47	1689	10/13/2001

Field 1 Fertilizer Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8075153	-102.8542095	47	1691	10/13/2001
2	51.8076709	-102.8527583	47	1690	10/13/2001
3	51.8074311	-102.8516113	47	1692	10/13/2001
4	51.8081737	-102.8486122	47	1691	10/13/2001
5	51.8080712	-102.8471076	47	1691	10/13/2001
6	51.8076515	-102.8458240	47	1689	10/13/2001

Field 1 Manure Lower Slope

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8052641	-102.8516928	47	1680	10/13/2001
2	51.8066147	-102.8492555	47	1681	10/13/2001
3	51.8024103	-102.8477951	47	1677	10/13/2001
4	51.8025236	-102.8508979	47	1679	10/13/2001
5	51.8035461	-102.8542118	47	1684	10/13/2001
6	51.8064468	-102.8537943	47	1689	10/13/2001

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 1 Manure Mid Slope

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8065669	-102.8508453	47	1681	10/13/2001
2	51.8069841	-102.8470812	47	1679	10/13/2001
3	51.8050359	-102.8465506	47	1679	10/13/2001
4	51.8026921	-102.8464146	47	1667	10/13/2001
5	51.8025586	-102.8516351	47	1675	10/13/2001
6	51.8044650	-102.8534343	47	1688	10/13/2001

Field 1 Manure Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8060338	-102.8485456	47	1682	10/13/2001
2	51.8043162	-102.8482396	47	1678	10/13/2001
3	51.8031796	-102.8504477	47	1673	10/13/2001
4	51.8027587	-102.8544405	47	1680	10/13/2001
5	51.8052813	-102.8545815	47	1684	10/13/2001
6	51.8066410	-102.8515662	47	1686	10/13/2001

Field 2 Fertilizer Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8253409	-102.8581941	47	1708	10/13/2001
2	51.8263235	-102.8583003	47	1709	10/13/2001
3	51.8281005	-102.8578101	47	1705	10/13/2001
4	51.8288236	-102.8580891	47	1705	10/13/2001
5	51.8292835	-102.8575373	47	1698	10/13/2001
6	51.8300593	-102.8579397	47	1697	10/13/2001

Field 2 Fertilizer Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8297247	-102.8577054	47	1704	10/13/2001
2	51.8288122	-102.8577205	47	1711	10/13/2001
3	51.8276033	-102.8579210	47	1713	10/13/2001
4	51.8266720	-102.8581034	47	1710	10/13/2001
5	51.8257462	-102.8578145	47	1706	10/13/2001
6	51.8248881	-102.8578580	47	1706	10/13/2001

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 2 Fertilizer Upper Slope

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8250591	-102.8581736	47	1705	10/12/2001
2	51.8261834	-102.8577223	47	1700	10/12/2001
3	51.8271563	-102.8581068	47	1702	10/12/2001
4	51.8281317	-102.8582915	47	1701	10/12/2001
5	51.8293282	-102.8580075	47	1700	10/12/2001
6	51.8298568	-102.8582003	47	1700	10/12/2001

Field 2 Manure Lower Slope

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8283861	-102.8675327	47	1704	10/13/2001
2	51.8271479	-102.8667147	47	1706	10/13/2001
3	51.8243495	-102.8660120	47	1702	10/13/2001
4	51.8262412	-102.8636996	47	1702	10/13/2001
5	51.8271340	-102.8611021	47	1705	10/13/2001
6	51.8293021	-102.8612060	47	1707	10/13/2001

Field 2 Manure Mid Slope

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8289166	-102.8624486	47	1707	10/13/2001
2	51.8264223	-102.8627127	47	1704	10/13/2001
3	51.8246278	-102.8630278	47	1706	10/13/2001
4	51.8242125	-102.8666802	47	1707	10/13/2001
5	51.8271417	-102.8680099	47	1713	10/13/2001
6	51.8294346	-102.8677285	47	1713	10/13/2001

Field 2 Manure Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8291212	-102.8602113	47	1715	10/13/2001
2	51.8268733	-102.8619298	47	1711	10/13/2001
3	51.8252154	-102.8605934	47	1710	10/13/2001
4	51.8250598	-102.8642966	47	1712	10/13/2001
5	51.8275107	-102.8660228	47	1717	10/13/2001
6	51.8295021	-102.8638509	47	1715	10/13/2001

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 3 Fertilizer Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7136012	-102.9729457	47	1728	10/12/2001
2	51.7135742	-102.9714499	47	1694	10/12/2001
3	51.7138251	-102.9698318	47	1692	10/12/2001
4	51.7136390	-102.9675022	47	1693	10/12/2001
5	51.7138775	-102.9665884	47	1694	10/12/2001
6	51.7136965	-102.9657836	47	1720	10/12/2001

Field 3 Fertilizer Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7135619	-102.9656762	47	1718	10/12/2001
2	51.7136781	-102.9672281	47	1718	10/12/2001
3	51.7136364	-102.9681214	47	1723	10/12/2001
4	51.7134805	-102.9701015	47	1717	10/12/2001
5	51.7138530	-102.9720192	47	1717	10/12/2001
6	51.7136952	-102.9742730	47	1723	10/12/2001

Field 3 Fertilizer Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7137862	-102.9735729	47	1724	10/12/2001
2	51.7134866	-102.9718423	47	1714	10/12/2001
3	51.7136969	-102.9708696	47	1712	10/12/2001
4	51.7135565	-102.9683524	47	1710	10/12/2001
5	51.7137074	-102.9667031	47	1709	10/12/2001
6	51.7137777	-102.9647292	47	1708	10/12/2001

Field 3 Manure Lower Slope

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7121529	-102.9736512	47	1717	10/12/2001
2	51.7124716	-102.9707210	47	1716	10/12/2001
3	51.7127607	-102.9652428	47	1728	10/12/2001
4	51.7107622	-102.9656826	47	1718	10/12/2001
5	51.7088995	-102.9667167	47	1718	10/12/2001
6	51.7102353	-102.9695978	47	1717	10/12/2001

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 3 Manure Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7096522	-102.9736099	47	1689	10/12/2001
2	51.7106916	-102.9708566	47	1691	10/12/2001
3	51.7097353	-102.9667710	47	1700	10/12/2001
4	51.7121980	-102.9659692	47	1705	10/12/2001
5	51.7124301	-102.9697703	47	1705	10/12/2001
6	51.7126427	-102.9729603	47	1711	10/12/2001

Field 3 Manure Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7118543	-102.9644876	47	1723	10/12/2001
2	51.7101445	-102.9651523	47	1713	10/12/2001
3	51.7098484	-102.9685195	47	1694	10/12/2001
4	51.7118593	-102.9678184	47	1730	10/12/2001
5	51.7120837	-102.9730399	47	1709	10/12/2001
6	51.7102209	-102.9736905	47	1711	10/12/2001

Field 4 Fertilizer Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7087909	-103.0333386	47	1684	10/11/2001
2	51.7100757	-103.0338096	47	1681	10/11/2001
3	51.7115839	-103.0332305	47	1689	10/11/2001
4	51.7108554	-103.0332610	47	1692	10/11/2001
5	51.7099220	-103.0332173	47	1687	10/11/2001
6	51.7076560	-103.0336613	47	1690	10/11/2001

Field 4 Fertilizer Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7085423	-103.0339682	47	1680	10/11/2001
2	51.7097765	-103.0337923	47	1681	10/11/2001
3	51.7112660	-103.0337168	47	1676	10/11/2001
4	51.7128923	-103.0336356	47	1673	10/11/2001
5	51.7114590	-103.0332063	47	1677	10/11/2001
6	51.7091282	-103.0332686	47	1672	10/11/2001

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 4 Fertilizer Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7080897	-103.0335392	47	1697	10/11/2001
2	51.7093905	-103.0337475	47	1697	10/11/2001
3	51.7110407	-103.0339113	47	1707	10/11/2001
4	51.7125844	-103.0340157	47	1711	10/11/2001
5	51.7122431	-103.0333569	47	1708	10/11/2001
6	51.7106892	-103.0332798	47	1711	10/11/2001

Field 4 Manure Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7087334	-103.0247087	47	1697	10/12/2001
2	51.7089121	-103.0281636	47	1698	10/12/2001
3	51.7103201	-103.0298860	47	1710	10/12/2001
4	51.7134408	-103.0312067	47	1707	10/12/2001
5	51.7130118	-103.0276299	47	1705	10/12/2001
6	51.7115556	-103.0251845	47	1707	10/12/2001

Field 4 Manure Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7076116	-103.0288933	47	1696	10/12/2001
2	51.7104870	-103.0303637	47	1706	10/12/2001
3	51.7124887	-103.0287879	47	1707	10/12/2001
4	51.7126321	-103.0250673	47	1707	10/12/2001
5	51.7102307	-103.0236886	47	1702	10/12/2001
6	51.7083417	-103.0240268	47	1692	10/12/2001

Field 4 Manure Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7084855	-103.0298007	47	1682	10/11/2001
2	51.7108790	-103.0292177	47	1683	10/11/2001
3	51.7132087	-103.0292352	47	1679	10/11/2001
4	51.7128815	-103.0259971	47	1678	10/11/2001
5	51.7092530	-103.0241203	47	1678	10/11/2001
6	51.7085717	-103.0267040	47	1680	10/11/2001

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 5 Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7997829	-102.8346645	47	1661	10/8/2002
2	51.7986188	-102.8353779	47	1659	10/8/2002
3	51.7963526	-102.8350991	47	1656	10/8/2002
4	51.7985520	-102.8392068	47	1661	10/8/2002
5	51.8007895	-102.8384436	47	1667	10/8/2002
6	51.8003838	-102.8416986	47	1664	10/8/2002
7	51.8004966	-102.8438437	47	1663	10/8/2002
8	51.7981672	-102.8424533	47	1660	10/8/2002
9	51.7963142	-102.8408686	47	1657	10/8/2002
10	51.7972551	-102.8442511	47	1657	10/8/2002

Field 5 Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7957579	-102.8433516	47	1665	10/8/2002
2	51.7970453	-102.8435062	47	1667	10/8/2002
3	51.7989984	-102.8425075	47	1670	10/8/2002
4	51.8009911	-102.8447223	47	1668	10/8/2002
5	51.8003088	-102.8396276	47	1666	10/8/2002
6	51.7981001	-102.8388482	47	1663	10/8/2002
7	51.7962677	-102.8373272	47	1663	10/8/2002
8	51.7953036	-102.8350157	47	1661	10/8/2002
9	51.7973292	-102.8350153	47	1663	10/8/2002
10	51.7995875	-102.8342536	47	1662	10/8/2002

Field 5 Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7952840	-102.8346828	47	1662	10/8/2002
2	51.7969781	-102.8356966	47	1665	10/8/2002
3	51.7984822	-102.8380653	47	1665	10/8/2002
4	51.8001638	-102.8381790	47	1668	10/8/2002
5	51.8007828	-102.8404756	47	1665	10/8/2002
6	51.8009385	-102.8436761	47	1669	10/8/2002
7	51.7988510	-102.8430436	47	1670	10/8/2002
8	51.7979165	-102.8403983	47	1663	10/8/2002
9	51.7957931	-102.8402845	47	1665	10/8/2002
10	51.7955511	-102.8435194	47	1665	10/8/2002

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 6 Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8071239	-102.8596659	47	1685	10/8/2002
2	51.8050139	-102.8583806	47	1685	10/8/2002
3	51.8067537	-102.8615292	47	1689	10/8/2002
4	51.8073440	-102.8645110	47	1692	10/8/2002
5	51.8078524	-102.8678948	47	1695	10/8/2002
6	51.8055841	-102.8661798	47	1692	10/8/2002
7	51.8036335	-102.8673024	47	1685	10/8/2002
8	51.8038723	-102.8645744	47	1687	10/8/2002
9	51.8032505	-102.8612113	47	1683	10/8/2002
10	51.8053168	-102.8609877	47	1684	10/8/2002

Field 6 Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8036645	-102.8610911	47	1689	10/8/2002
2	51.8021122	-102.8620382	47	1683	10/8/2002
3	51.8025251	-102.8664605	47	1687	10/8/2002
4	51.8051509	-102.8676259	47	1694	10/8/2002
5	51.8043675	-102.8642588	47	1692	10/8/2002
6	51.8073737	-102.8647450	47	1695	10/8/2002
7	51.8074832	-102.8677568	47	1700	10/8/2002
8	51.8078590	-102.8623081	47	1693	10/8/2002
9	51.8056060	-102.8608367	47	1694	10/8/2002
10	51.8067702	-102.8587632	47	1687	10/8/2002

Field 6 Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8020070	-102.8607734	47	1688	10/8/2002
2	51.8030090	-102.8641855	47	1693	10/8/2002
3	51.8025809	-102.8679588	47	1694	10/8/2002
4	51.8052851	-102.8667162	47	1700	10/8/2002
5	51.8049789	-102.8636811	47	1695	10/8/2002
6	51.8076417	-102.8670495	47	1698	10/8/2002
7	51.8066017	-102.8619156	47	1694	10/8/2002
8	51.8053791	-102.8586047	47	1687	10/8/2002
9	51.8041660	-102.8609031	47	1696	10/8/2002
10	51.8041928	-102.8608682	47	1694	10/8/2002

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 7 Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7086306	-102.9772979	47	1703	10/8/2003
2	51.7082988	-102.9796347	47	1700	10/8/2003
3	51.7077061	-102.9847231	47	1695	10/8/2003
4	51.7087071	-102.9854519	47	1698	10/8/2003
5	51.7119268	-102.9843964	47	1705	10/8/2003
6	51.7108098	-102.9809390	47	1706	10/8/2003
7	51.7110279	-102.9778674	47	1707	10/8/2003
8	51.7124591	-102.9769201	47	1707	10/8/2003
9	51.7130631	-102.9821077	47	1708	10/8/2003
10	51.7132331	-102.9841207	47	1707	10/8/2003

Field 7 Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7132997	-102.9856075	47	1711	10/8/2003
2	51.7130879	-102.9827041	47	1711	10/8/2003
3	51.7132950	-102.9783612	47	1714	10/8/2003
4	51.7119074	-102.9765249	47	1709	10/8/2003
5	51.7107376	-102.9793592	47	1704	10/8/2003
6	51.7102941	-102.9844326	47	1702	10/8/2003
7	51.7091421	-102.9824484	47	1698	10/8/2003
8	51.7084378	-102.9802347	47	1699	10/8/2003
9	51.7076693	-102.9775417	47	1698	10/8/2003
10	51.7097556	-102.9760325	47	1707	10/8/2003

Field 7 Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.7099817	-102.9761035	47	1710	10/8/2003
2	51.7090658	-102.9779894	47	1704	10/8/2003
3	51.7073886	-102.9805498	47	1695	10/8/2003
4	51.7086681	-102.9842904	47	1700	10/8/2003
5	51.7100609	-102.9811890	47	1704	10/8/2003
6	51.7116975	-102.9778358	47	1708	10/8/2003
7	51.7131905	-102.9766557	47	1716	10/8/2003
8	51.7137029	-102.9810466	47	1714	10/8/2003
9	51.7126287	-102.9842830	47	1710	10/8/2003
10	51.7135124	-102.9859238	47	1714	10/8/2003

APPENDIX A. SOIL BENCHMARK SAMPLE SITE LOCATION COORDINATES (cont'd)

Field 8 Lower Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8098476	-102.8703259	47	1703	10/8/2003
2	51.8109737	-102.8739751	47	1704	10/8/2003
3	51.8105817	-102.8787911	47	1707	10/8/2003
4	51.8122055	-102.8797880	47	1705	10/8/2003
5	51.8127142	-102.8763749	47	1707	10/8/2003
6	51.8122952	-102.8708494	47	1704	10/8/2003
7	51.8147039	-102.8700848	47	1702	10/8/2003
8	51.8141306	-102.8732856	47	1710	10/8/2003
9	51.8135823	-102.8757648	47	1706	10/8/2003
10	51.8139318	-102.8786068	47	1708	10/8/2003

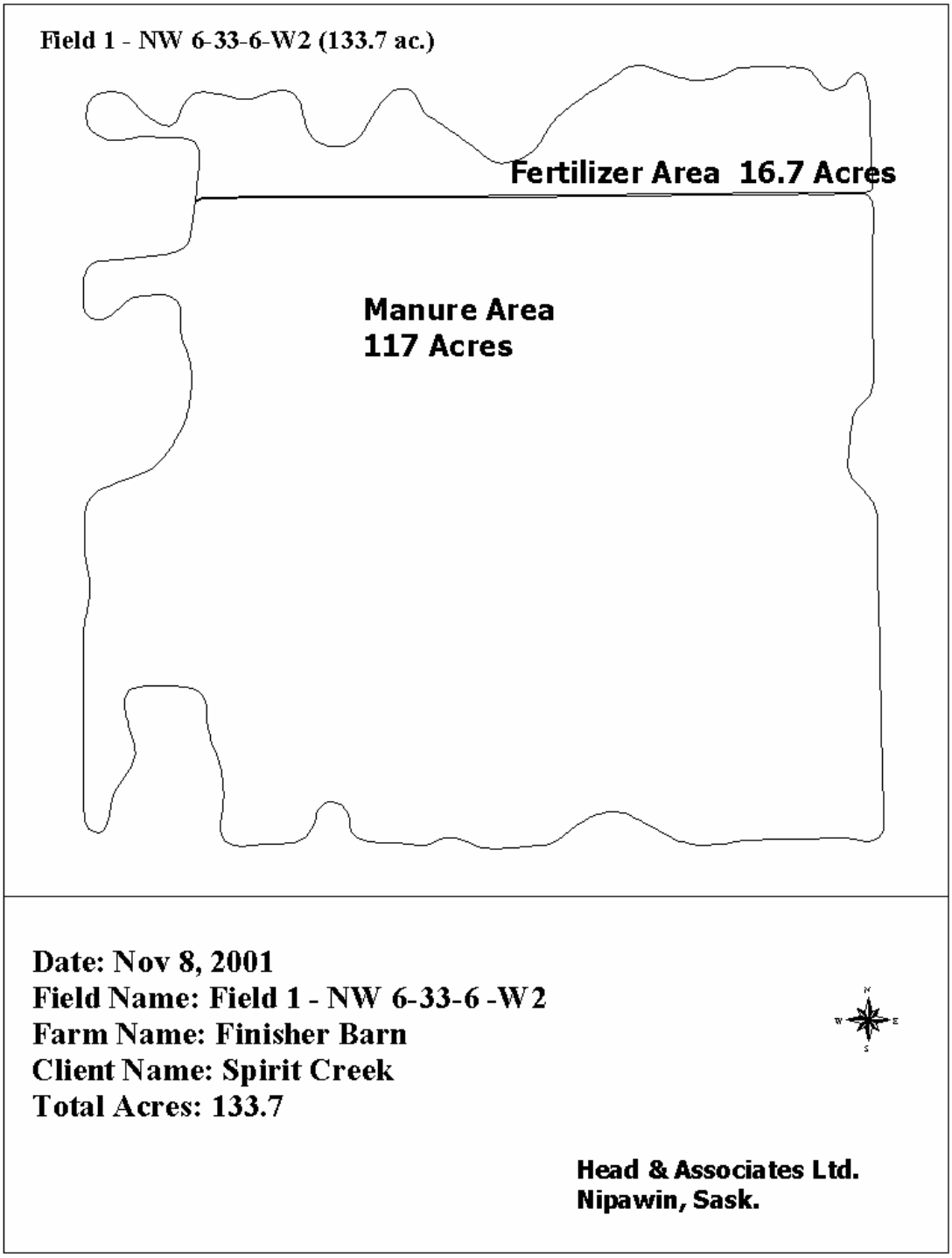
Field 8 Mid Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8146157	-102.8785027	47	1711	10/8/2003
2	51.8150217	-102.8759919	47	1708	10/8/2003
3	51.8136279	-102.8734566	47	1708	10/8/2003
4	51.8131960	-102.8702790	47	1706	10/8/2003
5	51.8117765	-102.8703197	47	1703	10/8/2003
6	51.8115306	-102.8752575	47	1708	10/8/2003
7	51.8112928	-102.8790698	47	1709	10/8/2003
8	51.8096821	-102.8799389	47	1711	10/8/2003
9	51.8094506	-102.8757634	47	1704	10/8/2003
10	51.8102542	-102.8700260	47	1703	10/8/2003

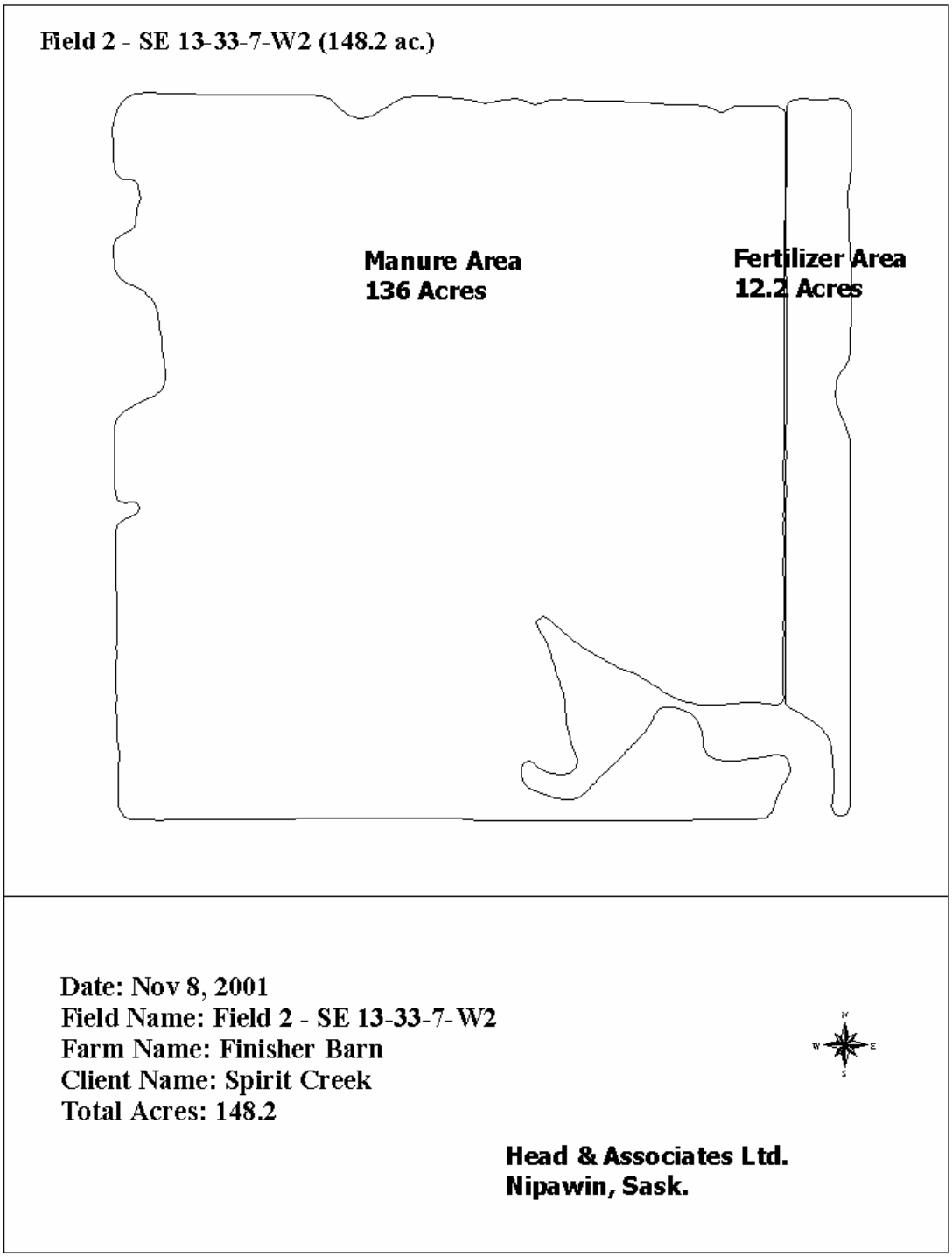
Field 8 Upper Slope Position

SAMPLE SITE	LATITUDE	LONGITUDE	DATUM	ALTITUDE	DATE
1	51.8098512	-102.8698574	47	1707	10/8/2003
2	51.8105566	-102.8726852	47	1707	10/8/2003
3	51.8101797	-102.8770253	47	1712	10/8/2003
4	51.8118790	-102.8802677	47	1711	10/8/2003
5	51.8129934	-102.8779948	47	1712	10/8/2003
6	51.8128229	-102.8742850	47	1706	10/8/2003
7	51.8131514	-102.8706157	47	1707	10/8/2003
8	51.8151565	-102.8714334	47	1712	10/8/2003
9	51.8148475	-102.8764042	47	1713	10/8/2003
10	51.8147910	-102.8785725	47	1714	10/8/2003

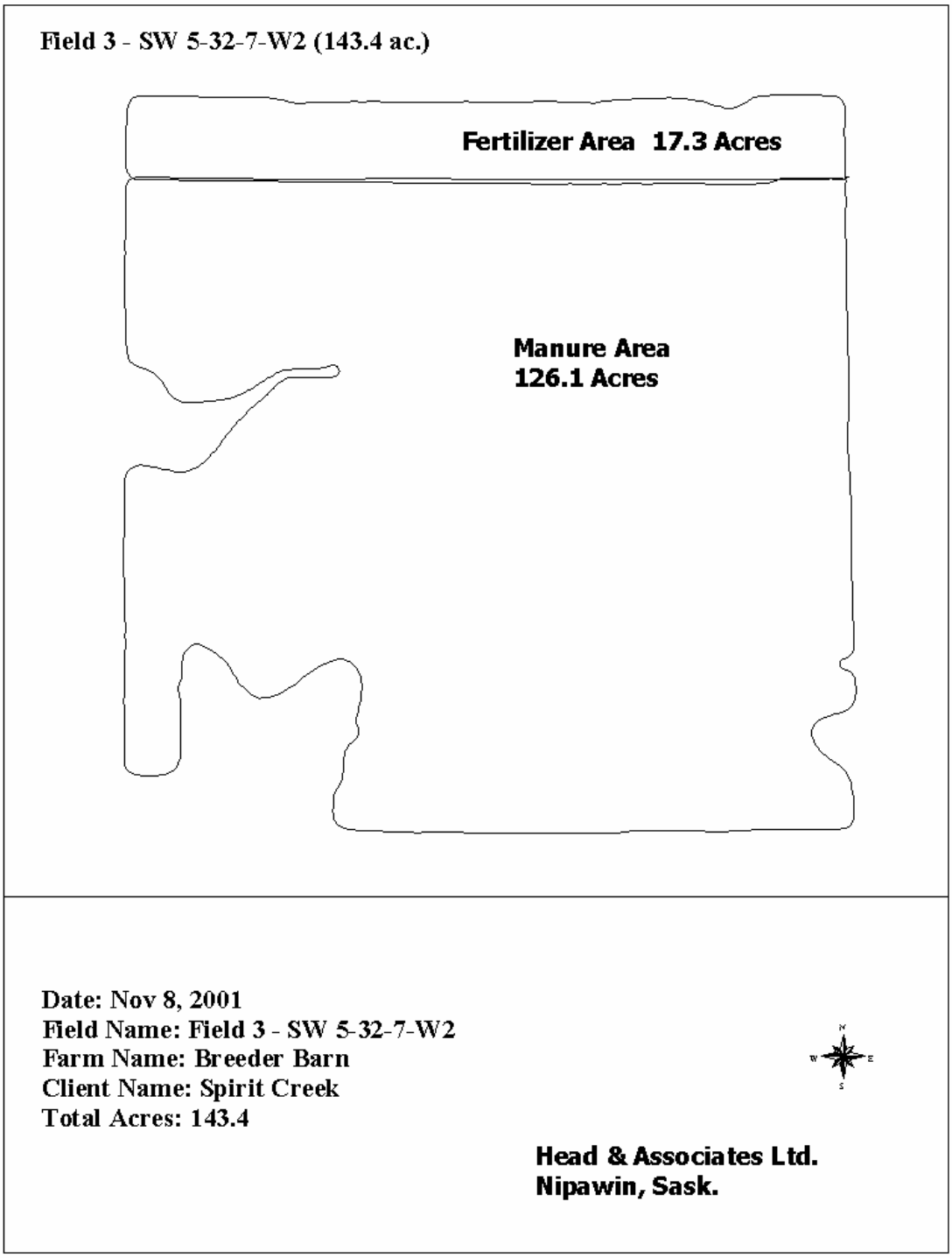
APPENDIX B. MAPS OF BENCHMARK FIELDS USED IN THE MANURE/COMMERCIAL FERTILIZER COMPARISON



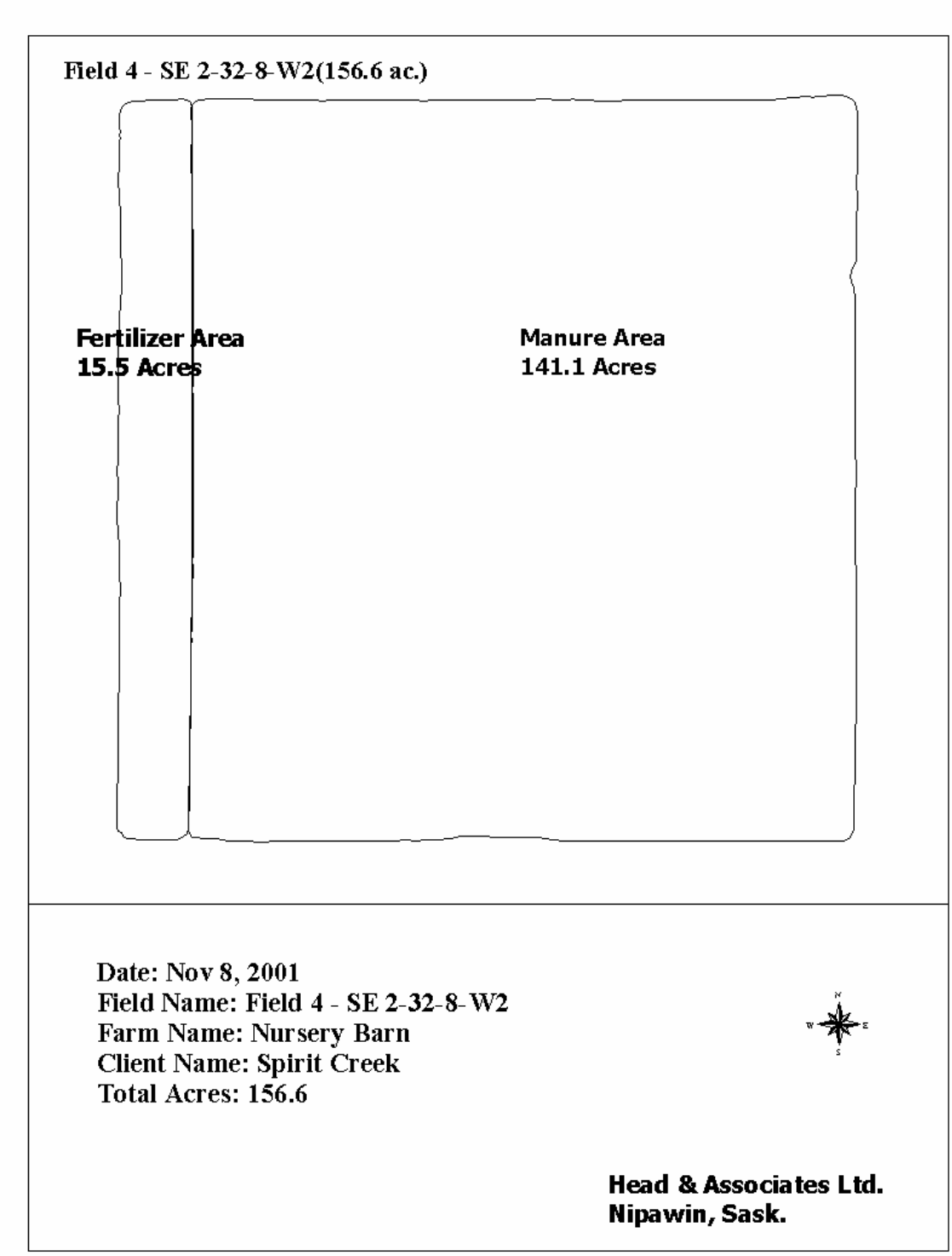
APPENDIX B. MAPS OF BENCHMARK FIELDS USED IN THE MANURE/COMMERCIAL FERTILIZER COMPARISON PROGRAM (cont'd)



APPENDIX B. MAPS OF BENCHMARK FIELDS USED IN THE MANURE/COMMERCIAL FERTILIZER COMPARISON PROGRAM (cont'd)



APPENDIX B. MAPS OF BENCHMARK FIELDS USED IN THE MANURE/COMMERCIAL FERTILIZER COMPARISON PROGRAM (cont'd)



APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS

Field 1 - Finisher Barn - NW 06-33-06-W2 - Manure Area – 117 acres

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK1-M-U*	0-12	8	6	476	493	25	2.5	91	16.0	1.4	1.1	1.4	2.3	0.1	8.6
		12-24	4		527		18								0.2	
		24-36	4				61								0.3	
		36-48	6				428								0.6	
2003	SK1-M-U	0-12	21	37		542	>86	2.9	86	16.3	3.0	3.7			0.5	7.9
		12-24	11				79								0.3	8.6
2004	SK1-M-U	0-12	18	31		529	>86								0.6	7.7
		12-24	11				56								0.3	8.5
2005	SK1-M-U	0-12	27	25	410	670	50	4.3	90	28.8	6.8	2.2	1.6	2.6	0.2	8.0
		12-24	16		480		36								0.3	
		24-36	18				83								0.3	
		36-48	14				1541								1.1	
2001	SK1-M-M	0-12	12	8	501	457	266	0.7	24	2.8	0.4	0.5	1.8	3.1	0.3	8.5
		12-24	4		540		878								1.2	
		24-36	4				1570								2.0	
		36-48	6				1418								1.3	
2003	SK1-M-M	0-12	72	31		609	>86	3.3	92	13.7	3.1	5.4			0.5	8.1
		12-24	12				>86								0.7	8.4
2004	SK1-M-M	0-12	15	24		542	>86								0.6	8.1
		12-24	6				>86								1.0	8.3
2005	SK1-M-M	0-12	45	40	440	752	79	4.3	94	21.6	7.2	3.2	2.0.	3.3	0.2	8.3
		12-24	21		380		832								0.8	
		24-36	14				2110								0.9	
		36-48	14				1390								1.4	

* SK1 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 1 - Finisher Barn - NW 06-33-06-W2 - Manure Area – 117 acres (cont'd)

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK1-M-L*	0-12	149	15	462	389	3896	1.8	168	5.8	2.9	1.8	4.1	7.1	1.7	7.9
		12-24	36		424		1418								1.4	
		24-36	15				842								1.2	
		36-48	14				1606								2.0	
2003	SK1-M-L	0-12	>144	52		505	>86	3.0	199	6.4	7.2	7.6			2.2	7.6
		12-24	64				>86								1.1	8.0
2004	SK1-M-L	0-12	73	51		544	>96								1.9	7.7
		12-24	77				>86								1.6	8.0
2005	SK1-M-L	0-12	79	68	510	749	3467	3.6	184	14.0	13.0	6.5	4.5	7.7	1.8	7.7
		12-24	87		360		2790								1.8	
		24-36	75				2326								1.1	
		36-48	52				3028								1.0	

* SK1 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 1 - Finisher Barn - NW 06-33-06-W2 – Fertilizer Area – 17 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK1-C-U*	0-12	12	9	554	400	25	2.5	49	13.0	1.1	1.1	1.3	2.3	0.1	8.7
		12-24	4		601		18								0.2	
		24-36	3				83								0.3	
		36-48	4				140								0.3	
2003	SK1-C-U	0-12	21	9		496	39	2.3	70	15.7	1.1	3.3			0.2	8.0
		12-24	10				29								0.2	8.6
2004	SK1-C-U	0-12	12	9		447	77								0.4	7.9
		12-24	7				38								0.3	8.5
2005	SK1-C-U*	0-12	18	14	500	662	25	3.2	122	40.0	7.2	2.5	1.7	3.0	0.3	8.1
		12-24	14		500		32								0.2	
		24-36	13				68								0.2	
		36-48	11				1584								0.8	
2001	SK1-C-M	0-12	12	9	511	428	1015	2.5	90	12.2	1.4	1.4	1.6	2.8	0.7	8.3
		12-24	4		552		784								1.1	
		24-36	3				741								0.9	
		36-48	4				1836								2.5	
2003	SK1-C-M	0-12	28	9		548	>86	3.0	101	12.3	2.3	5.3			0.8	7.9
		12-24	10				>86								1.3	8.2
2004	SK1-C-M	0-12	10	12		468	>86								1.0	7.7
		12-24	5				>86								1.6	8.1
2005	SK1-C-M*	0-12	19	11	440	655	1012	3.6	130	28.4	9.7	4.3	2.0	3.4	0.9	7.9
		12-24	15		500		2041								1.3	
		24-36	11				2038								1.2	
		36-48	9				900								0.9	

* SK1 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 1 - Finisher Barn - NW 06-33-06-W2 – Fertilizer Area – 17 acres (cont'd)

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK1-C-L*	0-12	15	108	660	504	2419	2.2	121	7.9	6.5	2.9	4.0	6.8	1.3	8.0
		12-24	3		456		3355								3.0	
		24-36	5				2182								2.3	
		36-48	10				914								1.1	
2003	SK1-C-L	0-12	25	90		497	>82	2.9	133	7.9	6.0	8.3			2.1	7.8
		12-24	5				>86								2.4	7.8
2004	SK1-C-L	0-12	21	107		545	>86								1.1	7.9
		12-24	7				>86								2.0	7.9
2005	SK1-C-L*	0-12	30	115	640	688	4140	3.6	184	23.8	14.0	7.9	3.8	6.6	2.4	7.8
		12-24	12		440		4464								2.5	
		24-36	15				3924								1.6	
		36-48	14				2012								0.9	

* SK1 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 2 - Finisher Barn - SE 13-33-07-W3 – Manure Area – 136 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK2-M-U*	0-12	13	30	384	490	32	2.5	68	17.3	2.5	0.7	1.0	1.8	0.1	8.6
		12-24	6		549		54								0.3	
		24-36	4				155								0.3	
		36-48	5				1706								1.3	
2003	SK2-M-U	0-12	73	21		578	33	3.4	101	19.9	1.7	2.5			0.3	8.0
		12-24	17				36								0.2	8.5
2004	SK2-M-U	0-12	12	24		563	32								0.3	8.0
		12-24	31				33								0.3	8.5
2005	SK2-M-U*	0-12	37	29	480	760	54	4.0	104	31.3	7.6	2.2	1.5	2.5	0.2	8.0
		12-24	23		480		40								0.2	
		24-36	44				241								0.3	
		36-48	35				1314								0.9	
2001	SK2-M-M	0-12	24	17	491	421	205	3.2	84	12.2	2.5	1.8	2.2	3.7	0.3	8.6
		12-24	5		536		2268								1.4	
		24-36	4				2650								1.9	
		36-48	4				2210								1.8	
2003	SK2-M-M	0-12	44	14		626	55	4.4	133	17.4	2.8	5.8			0.3	8.2
		12-24	17				71								0.2	8.6
2004	SK2-M-M	0-12	12	9		514	26								0.4	8.1
		12-24	12				69								0.4	8.5
2005	SK2-M-M*	0-12	40	11	460	644	36	5.0	97	24.5	6.1	2.9	2.1	3.6	0.2	8.2
		12-24	22		490		230								0.5	
		24-36	19				2466								1.5	
		36-48	32				4212								1.9	

* SK2 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 2 - Finisher Barn - SE 13-33-07-W3 – Manure Area – 136 acres (cont'd)

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK2-M-L*	0-12	109	28	592	331	3492	2.2	30	9.4	8.6	2.5	6.7	11	1.6	7.8
		12-24	73		425		3636								2.6	
		24-36	17				806								0.9	
		36-48	12				893								1.0	
2003	SK2-M-L	0-12	>160	34		615	>96	3.2	487	4.9	12.0	9.5			2.0	7.3
		12-24	55				>86								1.4	7.7
2004	SK2-M-L	0-12	70	18		431	>86								2.0	7.5
		12-24	84				>86								1.9	7.8
2005	SK2-M-L	0-12	90	32	650	504	3208	2.9	346	10.4	16.6	8.3	8.2	14	1.7	7.7
		12-24	104		390		4068								1.8	
		24-36	115				2149								0.9	
		36-48	71				1249								0.6	

* SK2 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 2 - Finisher Barn - SE 13-33-07-W3 – Fertilizer Area – 12 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK2-C-U*	0-12	14	30	377	540	61	2.2	81	17.3	2.5	0.7	1.5	2.5	0.2	8.5
		12-24	4		583		25								0.3	
		24-36	5				61								0.3	
		36-48	5				137								0.3	
2003	SK2-C-U	0-12	26	28		695	48	3.3	141	22.1	2.1	2.3			0.3	7.8
		12-24	34				30								0.3	8.2
2004	SK2-C-U	0-12	10	31		597	56								0.3	7.9
		12-24	9				57								0.2	8.3
2005	SK2-C-U*	0-12	26	22	360	745	50	4.0	173	40.3	7.9	1.8	1.7	2.9	0.2	7.9
		12-24	17		510		40								0.2	
		24-36	13				83								0.2	
		36-48	16				180								0.5	
2001	SK2-C-M	0-12	14	42	806	529	54	2.9	82	14.0	4.0	1.4	2.1	3.7	0.1	8.6
		12-24	5		518		223								0.3	
		24-36	4				367								0.4	
		36-48	4				482								0.5	
2003	SK2-C-M	0-12	18	40		685	69	3.4	144	17.5	5.9	4.5			0.3	7.9
		12-24	7				>86								0.4	8.3
2004	SK2-C-M	0-12	9	21		560	55								0.3	8.0
		12-24	6				>86								0.4	8.2
2005	SK2-C-M	0-12	27	43	410	796	25	5	180	31.3	11.2	2.9	2.3	4	0.2	8.1
		12-24	16		480		50								0.4	
		24-36	11				396								0.6	
		36-48	15				983								1	

* SK2 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 2 - Finisher Barn - SE 13-33-07-W3 – Fertilizer Area – 12 acres (cont'd)

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK2-C-L*	0-12	19	52	554	407	248	3.2	177	10.1	4.3	1.8	2.9	5.1	0.3	8.4
		12-24	6		544		248								0.4	
		24-36	4				169								0.4	
		36-48	5				198								0.3	
2003	SK2-C-L	0-12	24	43		508	>86	4.1	276	11.7	6.0	6.3			0.4	7.9
		12-24	12				>86								0.4	8.1
2004	SK2-C-L	0-12	16	58		471	>86								0.5	7.9
		12-24	10				>86								0.5	8.0
2005	SK2-C-L	0-12	35	76	550	580	212	4.7	230	18.0	9.4	5.0	3.7	6.4	0.4	8.1
		12-24	19		500		173								0.3	
		24-36	21				259								0.4	
		36-48	20				292								0.5	

* SK2 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 3 - Breeder Barn - SW 05-32-07-W2 – Manure Area – 126 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK3-M-U*	0-12	31	19	620	421	518	1.8	24	12.2	0.7	1.4	1.8	3	0.4	8.3
		12-24	5		543		241								0.4	
		24-36	18				1267								1.0	
		36-48	39				979								1.0	
2003	SK3-M-U	0-12	23	12		542	61	2.2	61	11.4	1.8	4.4			0.2	8.4
		12-24	27				>86								0.8	8.5
2004	SK3-M-U	0-12	10	18		502	27								0.3	8.1
		12-24	9				57								0.2	8.6
2005	SK3-M-U*	0-12	33	18	540	742	40	2.9	43	18.4	6.8	2.9	2.1	3.6	0.2	8.4
		12-24	19		480		54								0.2	
		24-36	17				1210								0.7	
		36-48	17				3053								0.8	
2001	SK3-M-M	0-12	10	27	445	561	454	1.8	53	11.5	1.8	1.4	2.7	4.6	0.5	8.3
		12-24	4		357		1944								1.6	
		24-36	8				2347								1.9	
		36-48	9				2369								1.8	
2003	SK3-M-M	0-12	41	31		526	>86	1.9	81	10.1	2.9	5.7			0.6	8.1
		12-24	14				>86								1.5	8.3
2004	SK3-M-M	0-12	13	15		428	>86								0.3	8.1
		12-24	9				>86								1.3	8.2
2005	SK3-M-M	0-12	32	32	460	724	382	2.9	79	19.1	6.8	4.7	2.8	4.8	0.4	8.1
		12-24	14		340		1890								0.9	
		24-36	17				3175								1.4	
		36-48	19				3103								1.2	

* SK3 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 3 - Breeder Barn - SW 05-32-07-W2 – Manure Area – 126 acre (cont'd)s

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK3-M-L*	0-12	17	51	584	522	3197	2.2	106	10.8	4.7	1.8	4.7	8.1	1.4	7.9
		12-24	6		452		1598								1.2	
		24-36	4				2038								1.4	
		36-48	7				1375								1.1	
2003	SK3-M-L	0-12	94	52		664	>86	2.7	145	9.4	6.7	7.7			1.4	7.8
		12-24	13				>86								1.2	8.0
2004	SK3-M-L	0-12	23	52		673	>86								0.7	7.7
		12-24	21				>86								1.1	8.0
2005	SK3-M-L	0-12	27	54	530	950	324	3.6	126	32.4	10.8	8.3	4.7	8.0	0.3	8.0
		12-24	17		330		598								0.4	
		24-36	16				2592								1.0	
		36-48	20				1778								0.8	

* SK3 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 3 - Breeder Barn - SW 05-32-07-W2 – Fertilizer Area – 17 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK3-C-U*	0-12	30	16	594	511	173	1.8	48	14.4	1.4	1.4	2.6	4.6	0.3	8.4
		12-24	6		522		928								0.8	
		24-36	7				979								0.9	
		36-48	10				1044								1.0	
2003	SK3-C-U	0-12	18	6		438	48	2.0	60	10.8	1.4	4.7			0.2	8.3
		12-24	9				>86								0.8	8.5
2004	SK3-C-U	0-12	10	7		449	38								0.2	8.2
		12-24	6				>96								0.9	8.3
2005	SK3-C-U*	0-12	27	7	490	619	83	2.9	58	20.1	4.0	3.6	2.1	3.6	0.2	8.1
		12-24	18		470		263								0.3	
		24-36	14				965								0.6	
		36-48	17				1548								0.8	
2001	SK3-C-M	0-12	27	25	503	565	1461	2.2	83	15.1	2.2	1.8	2.9	5	0.8	8.1
		12-24	6		481		3924								2.1	
		24-36	6				4824								2.0	
		36-48	8				4680								3.0	
2003	SK3-C-M	0-12	15	12		539	43	2.2	93	12.1	2.0	5.1			0.2	8.2
		12-24	6				>86								1.3	8.4
2004	SK3-C-M	0-12	11	10		520	41								0.3	8.1
		12-24	7				>96								0.6	8.4
2005	SK3-C-M	0-12	28	7	490	738	97	2.9	83	22.7	5.0	3.6	3.1	5.3	0.2	8.1
		12-24	17		480		904								0.5	
		24-36	17				2660								1.0	
		36-48	19				4068								1.3	

* SK3 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 3 - Breeder Barn - SW 05-32-07-W2 – Fertilizer Area – 17 acres (cont'd)

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK3-C-L*	0-12	20	89	526	824	3038	2.5	129	15.1	4.3	1.8	3.3	5.7	1.3	7.8
		12-24	6		457		1310								0.9	
		24-36	5				2974								1.5	
		36-48	5				2441								1.8	
2003	SK3-C-L	0-12	19	15		566	>86	2.8	163	12.0	3.3	4.9			0.4	7.8
		12-24	6				>86								1.0	7.9
2004	SK3-C-L	0-12	17	21		548	>86								0.4	7.6
		12-24	12				>86								0.9	7.7
2005	SK3-C-L	0-12	22	18	590	630	1076	3.6	133	25.6	6.5	4.7	4.0	6.8	0.7	7.6
		12-24	14		440		1458								0.9	
		24-36	13				3071								1.0	
		36-48	11				2167								1.0	

* SK3 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 4 - Nursery - SE 02-32-08-W2 – Manure Area – 141 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK4-M-U*	0-12	31	19	666	421	518	1.8	37	15.8	1.4	2.5	3.0	5.2	0.4	8.3
		12-24	17		507		4356								2.5	
		24-36	14				4464								2.9	
		36-48	14				4320								2.9	
2003	SK4-M-U	0-12	>144	9		548	>86	2.3	35	7.8	1.8	6.3			0.7	8.2
		12-24	34				>86								1.6	8.2
2004	SK4-M-U	0-12	17	14		653	>96								1.2	7.8
		12-24	35				>86								1.8	8.2
2005	SK4-M-U*	0-12	49	18	590	767	2480	2.5	54	17.3	14.0	4.0	2.7	4.7	1.0	7.9
		12-24	40		490		3744								1.5	
		24-36	102				4248								2.2	
		36-48	115				3816								2.1	
2001	SK4-M-M	0-12	18	27	521	562	454	2.5	71	15.1	1.8	2.2	2.9	5	0.5	8.3
		12-24	10		491		1534								1.2	
		24-36	7				1037								1.6	
		36-48	9				2527								1.9	
2003	SK4-M-M	0-12	56	28		737	>86	2.6	84	13.1	2.0	7.9			1.0	8.1
		12-24	21				>86								1.7	8.3
2004	SK4-M-M	0-12	20	24		741	>96								1.0	8.0
		12-24	14				>96								1.5	8.2
2005	SK4-M-M	0-12	51	25	590	979	810	3.6	101	18.4	7.6	7.2	3.4	5.9	0.5	8.2
		12-24	35		410		3168								1.2	
		24-36	50				2686								1.3	
		36-48	19				2030								1.0	

* SK4 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 4 - Nursery - SE 02-32-08-W2 – Manure Area – 141 acres (cont'd)

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK4-M-L*	0-12	17	51	537	522	3196	2.9	91	12.2	4.0	1.8	3.8	6.5	1.4	7.9
		12-24	5		487		2160								1.6	
		24-36	5				623								0.6	
		36-48	6				374								0.4	
2003	SK4-M-L	0-12	48	55		814	>86	4.1	152	15.4	5.8	6.9			1.2	7.8
		12-24	18				>86								0.7	8.1
2004	SK4-M-L	0-12	29	78		969	>96								0.8	7.9
		12-24	19				>96								0.9	8.0
2005	SK4-M-L	0-12	26	90	540	1170	443	4.7	184	40.0	15.5	6.1	4.0	6.9	0.6	8.1
		12-24	14		480		1253								0.7	
		24-36	14				1220								0.8	
		36-48	21				1001								0.6	

* SK4 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 4 - Nursery - SE 02-32-08-W2 – Fertilizer Area – 15 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK4-C-U*	0-12	30	16	669	511	173	2.2	46	17.3	2.2	2.5	3.4	5.8	0.3	8.4
		12-24	9		521		1663								1.4	
		24-36	12				5076								3.2	
		36-48	13				5760								3.5	
2003	SK4-C-U	0-12	18	3		511	>86	2.5	66	13.5	1.7	6.5			0.3	8.4
		12-24	8				>86								1.8	8.4
2004	SK4-C-U	0-12	19	10		585	>96								0.3	8.0
		12-24	9				>86								0.7	8.3
2005	SK4-C-U*	0-12	36	11	660	691	126	2.9	72	25.2	7.9	4.0	4.1	7.0	0.3	8.3
		12-24	15		480		1188								1.1	
		24-36	17				2038								1.4	
		36-48	22				2484								1.7	
2001	SK4-C-M	0-12	27	25	594	565	1462	2.9	73	20.2	2.5	2.2	3.2	5.5	0.8	8.1
		12-24	13		436		3420								2.4	
		24-36	8				3341								2.2	
		36-48	10				5508								3.4	
2003	SK4-C-M	0-12	18	9		679	>86	2.7	75	14.1	2.1	7.7			1.1	8.1
		12-24	7				>86								1.9	8.4
2004	SK4-C-M	0-12	18	17		721	>96								0.5	7.9
		12-24	10				>96								1.6	8.1
2005	SK4-C-M	0-12	39	11	560	788	788	3.6	72	20.9	9.0	6.5	3.0	5.2	0.6	8.2
		12-24	18		440		2282								1.3	
		24-36	23				3744								1.6	
		36-48	26				4140								2.0	

* SK4 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 4 - Nursery - SE 02-32-08-W2 – Fertilizer Area – 15 acres (cont'd)

Year	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			lb/ac	lb/ac	ug/g**	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	%	%	mS/cm	
2001	SK4-C-L*	0-12	20	89	549	824	3038	4.0	130	13.0	4.7	2.2	3.8	6.5	1.3	7.8
		12-24	8		489		1714								1.3	
		24-36	10				1591								1.2	
		36-48	12				2246								1.5	
2003	SK4-C-L	0-12	31	55		881	>86	3.0	103	12.7	4.1	7.4			1.7	7.9
		12-24	21				>86								1.7	8.0
2004	SK4-C-L	0-12	19	58		877	>96								1.3	7.7
		12-24	19				>106								1.5	7.8
2005	SK4-C-L	0-12	22	104	540	929	2286	4.0	176	36.0	9.7	5.0	3.3	5.7	1.2	7.7
		12-24	22		590		2430								1.2	
		24-36	31				3852								1.6	
		36-48	30				4392								1.7	

* SK4 = Field number; M = Manure; C = Fertilizer; U = Upper Slope; M = Mid Slope; L = Lower Slope

** ug/g times 4 = lb/ac

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 5 - Finisher Barn - SE 6-33-06-W2 – 135 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			ug/cc*	ug/cc	ug/g**	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	%	%	mS/cm	
Upper	SK5-U	0-12	4.4	2.0	430	103	14	0.7	18.0	4.3	0.5	1.1	1.9	3.4	0.2	8.5
		12-24	3.4		410		14								0.2	
		24-36	3.0				670								1.0	
		36-48	3.4				1050								1.6	
Mid	SK5-M	0-12	5.2	4.0	430	114	402	0.7	23.0	5.4	0.5	1.7	2.5	4.5	0.8	8.2
		12-24	5.6		370		1210								1.4	
		24-36	5.0				1120								1.4	
		36-48	6.0				664								1.0	
Lower	SK5-L	0-12	21.4	54.0	820	322	1070	1.0	69.0	6.8	5.6	2.7	6.1	11.0	2.1	7.8
		12-24	16.2		340		1070								1.7	
		24-36	11.2				891								1.3	
		36-48	2.8				1050								1.4	

Field 6 - Finisher Barn - NE 1-33-07-W2 – 137 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			ug/cc*	ug/cc	ug/g**	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	%	%	mS/cm	
Upper	SK6-U	0-12	7.0	11.0	340	190	18	0.9	43.0	10.4	0.9	0.9	1.8	3.2	0.2	8.0
		12-24	4.4		360		14								0.1	
		24-36	3.8				38								0.2	
		36-48	3.0				64								0.3	
Mid	SK6-M	0-12	7.4	6.0	290	171	658	0.9	47.0	8.4	0.7	1.1	2.0	3.6	1.1	7.8
		12-24	4.4		350		259								0.7	
		24-36	3.0				293								0.8	
		36-48	2.4				340								0.8	
Lower	SK6-L	0-12	11.6	19.0	420	199	296	1.1	97.0	6.8	1.3	1.7	2.6	4.8	0.9	7.8
		12-24	3.0		390		756								1.0	
		24-36	2.0				658								1.1	
		36-48	2.8				535								0.8	

* SK5 = Field Number; U = Upper slope, M = Mid Slope, L = Lower Slope

** ug/cc times 3.6 = pounds/acre ***ug/g times 4 = pounds/acre

APPENDIX C. SOIL BENCHMARK ANALYTICAL RESULTS (cont'd)

Field 7 - Breeder Barn - SE 6-32-07-W2 – 151 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			ug/cc**	ug/cc	ug/g***	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	%	%	mS/cm	
Upper	SK7-U*	0-12	36.6	27.0	580	159	667	0.8	11.0	2.2	1.3	1.4	1.8	3.2	1.0	8.2
		12-24	6.0		450		170								0.5	
		24-36	2.6				660								1.0	
		36-48	3.0				1410								2.2	
Mid	SK7-M	0-12	40.0	63.0	610	139	367	0.6	9.0	2.5	3.4	2.1	3.2	5.7	0.8	8.2
		12-24	5.4		410		900								1.6	
		24-36	4.6				1550								2.1	
		36-48	5.2				1520								2.8	
Lower	SK7-L	0-12	36.4	32.0	590	139	578	0.6	21.0	2.1	1.5	2.5	4.2	7.6	1.3	8.0
		12-24	7.4		450		519								1.2	
		24-36	6.2				287								0.7	
		36-48	5.8				244								0.7	

Field 8 - Finisher Barn - SW 12-33-07-W2 – 146 acres

Slope	Sample	Depth	N	P	Total P	K	S	Cu	Fe	Mn	Zn	B	Org C	O.M.	EC	pH
			ug/cc**	ug/cc	ug/g***	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	ug/cc	%	%	mS/cm	
Upper	SK8-U*	0-12	6.0	2.0	390	131	587	1.0	16.0	3.0	0.6	1.1	1.3	2.3	1.0	7.9
		12-24	3.2		410		855								1.2	
		24-36	2.6				1150								1.1	
		36-48	2.2				1160								1.2	
Mid	SK8-M	0-12	3.4	2.0	370	95	109	0.6	15.0	2.6	0.4	1.6	1.7	3	0.4	8.3
		12-24	1.8		390		619								0.9	
		24-36	1.6				944								1.2	
		36-48	2.0				722								0.9	
Lower	SK8-L	0-12	17.0	6.0	460	126	1410	0.7	50.0	1.4	1.9	2.6	4.2	7.5	2.5	7.7
		12-24	9.0		390		1310								2.1	
		24-36	4.6				877								1.5	
		36-48	4.0				541								1.1	

* SK7 = Field Number; U = Upper slope, M = Mid Slope, L = Lower Slope

** ug/cc times 3.6 = pounds/acre ***ug/g times 4 = pounds/acre

APPENDIX D. MANURE ANLAYTICAL RESULTS

MANURE ANALYTICAL RESULTS - 2002

Nursery Barn (Main Road)

Source	Sample	NH4-N	Total N	P	K	S	Na	Ca	Mg	Cu	Fe	Mn	Zn	Solids	EC	pH
		Pounds/1000 gal												%	µS/cm	
Lagoon	1	29	34	2.0	22	2	3	3.0	<1	<0.01	<0.01	<0.01	<0.01	2.3	15600	7.4
	2	26	29	<1	19	1	3	2.0	<1	<0.01	<0.01	<0.01	<0.01	1.2	10800	7.7
	3	26	29	<1	23	2	3	3.0	<1	<0.01	<0.01	<0.01	<0.01	1.5	12000	7.6
	4	29	34	2.0	21	2	2	3.0	<1	<0.01	<0.01	<0.01	<0.01	1.9	13300	7.3
Field	1-NW	30	35	2.0	22	2	3	3.0	1.0	<0.01	<0.01	<0.01	<0.01	1.9	15400	7.5
	2-SW	31	37	3.0	22	3	4	4.0	2.0	<0.01	<0.01	<0.01	<0.01	2.0	19200	7.3
	3-NE	31	36	2.0	22	3	4	3.0	1.0	<0.01	<0.01	<0.01	<0.01	1.8	15700	7.3
	4-SE	30	35	2.0	22	2	4	3.0	1.0	<0.01	<0.01	<0.01	<0.01	1.9	20100	7.3

Breeder Barn (Korchinski)

Source	Sample	NH4-N	Total N	P	K	S	Na	Ca	Mg	Cu	Fe	Mn	Zn	Solids	EC	pH
		Pounds/1000 gal												%	µS/cm	
Lagoon	1	20	24	2	13	1	2	4	1	<0.01	<0.01	<0.01	<0.01	1.1	9900	7.8
	2	22	25	2	13	2	3	3	<1	<0.01	<0.01	<0.01	<0.01	1.2	15100	7.4
	3	21	25	1	13	1	3	3	<1	<0.01	<0.01	<0.01	<0.01	1.2	12800	7.5
	4	20	24	1	15	1	3	4	<1	<0.01	1.0	<0.01	<0.01	1.4	14900	7.4

Finisher Barn (Matsalla)

Source	Sample	NH4-N	Total N	P	K	S	Na	Ca	Mg	Cu	Fe	Mn	Zn	Solids	EC	pH
		Pounds/1000 gal												%	µS/cm	
Lagoon	1	30	35	<1	20	2	8	4	<1	<0.01	<0.01	<0.01	<0.01	2.2	19900	7.5
	2	28	31	<1	20	2	9	4	<1	<0.01	<0.01	<0.01	<0.01	2.3	21100	7.7
	4	30	33	<1	21	2	8	4	1	<0.01	<0.01	<0.01	<0.01	1.8	21700	7.6

APPENDIX D. MANURE ANLAYTICAL RESULTS (cont'd)

MANURE ANALYTICAL RESULTS - 2003

Finisher Barn (Nieckar)

Source	Sample	NH4-N	Total N	P	K	S	Na	Ca	Mg	Cu	Fe	Mn	Zn	Solids	EC	pH
		Pounds/1000 gal												%	µS/cm	
Pump	1-NW	35	39	2	19	3	9	4	1	0.03	0.34	0.03	0.08	2.0	21600	7.5
	3-NE	37	44	4	19	4	9	5	2	0.03	0.50	0.05	0.14	2.5	21800	7.3
	5-SW	38	46	5	18	4	8	6	4	0.04	0.57	0.07	0.23	3.0	21700	7.3
	7-SE	36	41	2	19	3	9	4	1	0.02	0.23	0.03	0.07	1.8	22200	7.5
Field 2	2-NW	35	40	2	19	3	9	4	1	0.01	0.28	0.02	0.07	1.9	22100	7.4
	4-NE	37	43	3	19	4	10	5	2	0.02	0.35	0.04	0.13	2.4	22300	7.3
	6-SW	37	43	4	19	4	10	5	2	0.02	0.37	0.05	0.14	2.4	22500	7.3
	8-SE	35	40	2	19	3	9	4	<1	0.01	0.14	0.02	0.06	1.7	21900	7.4

Finisher Barn (Matsalla)

Source	Sample	NH4-N	Total N	P	K	S	Na	Ca	Mg	Cu	Fe	Mn	Zn	Solids	EC	pH
		Pounds/1000 gal												%	µS/cm	
Pump	2-SE	41	57	17	19	6	8	15	13	0.12	1.95	0.21	0.71	7.5	11600	7.0
	4-SW	41	58	18	19	6	10	15	13	0.11	1.66	0.21	0.74	8.1	10800	7.0
	6-NE	41	49	18	19	6	8	15	13	0.16	1.85	0.21	0.76	7.7	9100	7.0
	8-NW	41	47	13	19	5	8	13	10	0.09	1.33	0.17	0.56	5.9	18800	6.9
Field 1	1-SE	41	56	17	19	6	8	15	13	0.10	1.64	0.21	0.67	8.0	17200	7.0
	3-SW	41	59	17	19	6	9	15	13	0.10	1.54	0.21	0.71	8.1	16400	6.9
	5-NE	42	50	18	19	6	9	15	14	0.10	1.66	0.22	0.74	8.2	8430	6.8
	7-NW	39	55	16	19	6	8	14	12	0.09	1.49	0.20	0.63	6.7	12700	6.9

APPENDIX E. MANURE APPLICATION HISTORY

SPRING 2002		FALL 2002	
LOCATION	**RATE (gal/ac)**	**LOCATION**	**RATE (gal/ac)**
NW 5-32-7-W2	9485	SW 5-32-7-W2	10874
NE 5-32-7-W2	9495	NE 7-32-7-W2	10492
NW 35-32-7-W2	8178	NE 8-32-7-W2	10917
NW 1-32-8-W2	8957	SE 2-32-8-W2	8543
SE 11-32-8-W2	11637	NE 2-32-8-W2	8411
SW 12-32-8-W2	7836		
SW 18-33-6-W2	8110		

SPRING 2003		FALL 2003	
LOCATION	**RATE (gal/ac)**	**LOCATION**	**RATE (gal/ac)**
NW 4-32-7-W2	10966	NE 26-31-8-W2	13449
SE 7-32-7-W2	10749	SE 35-31-8-W2	11410
SW 7-32-7-W2	9938	SE 5-32-7-W2	10340
NW 6-66-6-W2	8302	SE 6-32-7-W2	10098
SW 7-33-6-W2	10666	SW 8-32-7-W2	8347
SE 12-33-7-W2	10,666	SE 36-32-7-W2	9269
SE 13-33-7-W2	8003	NE 1-32-8-W2	8911
		SE 12-32-8-W2	8971
		SE 6-33-6-W2	8306
		SE 7-33-6-W2	9594
		NE 1-33-7-W2	9277

APPENDIX E. MANURE APPLICATION HISTORY (cont'd)

SPRING 2004		FALL 2004	
LOCATION	**RATE (gal/ac)**	**LOCATION**	**RATE (gal/ac)**
NW 9-32-7-W2	10332	NW 31-31-7-W2	14974
SE 17-32-7-W2	10113	SE 35-31-8-W2	10339
SW 17-32-7-W2	11731	NW 5-32-7-W2	10455
SW 1-32-8-W2	13569	NW 8-32-7-W2	11483
NW 1-32-8-W2	10673	SE 17-32-7-W2	10529
NE 6-33-6-W2	9957	SW 18-32-7-W2	10341
NW 7-33-6-W2	10625	NW 18-32-7-W2	10565
SW 1-33-7-W2	8050	NE 36-32-7-W2	4547
SE 2-33-7-W2	8296	NE 2-32-8-W2	12061
		SE 11-32-8-W2	9496
		SW 12-32-8-W2	5913
		SE 12-33-7-W2	10089
		NE 12-33-7-W2	10349

SPRING 2005		FALL 2005	
LOCATION	**RATE (gal/ac)**	**LOCATION**	**RATE (gal/ac)**
SE 8-32-7-W2	9783	NE 31-31-7-W2	12000
SE 9-32-7-W2	8256	NW 32-31-7-W2	10000
SE 1-32-8-W2	11489	NW 35-31-8-W2	12000
NW 2-32-8-W2	11673	SW 36-31-8-W2	10000
NE 3-32-8-W2	9020	NW 36-31-8-W2	10000
SW 7-33-6-W2	10317	NE 36-31-8-W2	10000
SE 11-33-7-W2	8161	SW 5-32-7-W2	10119
SW 12-33-7-W2	10452	NW 7-32-7-W2	8000
		NE 7-32-7-W2	10020
		NE 8-32-7-W2	9000
		NE 11-32-8-W2	8500
		NE 12-32-8-W2	10000
		NW 6-33-6-W2	10000
		NW 7-33-6-W2	10000
		SE 13-33-7-W2	10000