

# **ECONOMIC ASSESSMENT OF MANURE PHOSPHORUS REGULATIONS FOR MANITOBA'S PIG INDUSTRY**

## **PART 2 OVERALL IMPACT AT THE PROVINCIAL SCALE**

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**FINAL REPORT**

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# **ECONOMIC ASSESSMENT OF MANURE PHOSPHORUS REGULATIONS FOR MANITOBA'S PIG INDUSTRY: OVERALL IMPACT AT THE PROVINCIAL SCALE**

## **EXECUTIVE SUMMARY**

New phosphorus regulations for pig producers in Manitoba have been proposed. To comply with the proposed regulations, producers will be required to make changes in their managing of pig manure. These changes will come at some cost.

Part 1 of this study (Salvano et al 2006) has outlined the proposed phosphorus regulations, namely the maximums of two-times the removal rate of phosphorus and one-times the removal rate of phosphorus. It also has outlined the framework for analysis of related changed manure management costs and has assigned unit costs to each of the alternative activities involved. Part 2 (this part) applies the framework to the Manitoba pig industry to determine an estimated additional annual cost to the industry for compliance to the proposed phosphorus regulations.

The additional costs to individual operations have been estimated. These estimates have been aggregated to determine estimated added Provincial costs. The estimated added annual cost to the Manitoba pig industry under a maximum threshold regulation of 2xPhosphorus removal rate is 17.88 million dollars and the estimated added annual cost to the industry under a maximum threshold regulation of 1xPhosphorus removal rate regulation is 27.86 million dollars.

The added annual costs are not distributed evenly across the Province. Under the 1xPhosphorus removal threshold regulation, the R.M. of Hanover faces the greatest added annual cost of 6.68 million dollars. La Broquerie, De Salaberry, Morris, and Ste. Anne follow, with additional annual cost estimates of 2.92, 1.87, 1.61 and 1.21 million dollars respectively.

The added annual costs are also not distributed evenly across all operations. Operations with enough land face less added costs than those that require trucking or treatment. Under the 1xPhosphorus removal threshold and estimate of 56.87 percent of operations have enough land available, while 9.75 percent of operations will truck up to 20 km, 4.58 percent will truck up to 40 km and 28.79 percent will treat manure.

The estimated added annual cost to the Manitoba pig industry under a maximum threshold regulation of 2xPhosphorus removal of 17.88 million dollars represents about 18% of the estimated annual 2005 net income accruing to pig producers in the Province. The estimated added annual cost under a maximum threshold regulation of 1xPhosphorus removal of 27.86 million dollars represents about 28% of the estimated annual 2005 net income accruing to pig producers in the province.

# ECONOMIC ASSESSMENT OF NEW PHOSPHORUS REGULATIONS: PART 2

## TABLE OF CONTENTS

|   |   |
|---|---|
| <b>EXECUTIVE SUMMARY.....</b>   | <b>I</b>  |
| <b>TABLE OF CONTENTS.....</b>   | <b>III</b>  |
| <b>LIST OF TABLES.....</b>  | <b>IV</b>   |
| <b>LIST OF FIGURES.....</b>   | <b>IV</b>   |
| <b>INTRODUCTION.....</b>  | <b>1</b>  |
| <b>1. OBJECTIVE.....</b>  | <b>1</b>  |
| <b>2. METHOD.....</b>   | <b>1</b>  |
| 2.1 Total Manure Produced.....  | 3   |
| 2.2 Maximum Application Based on Nitrogen Removal .....   | 4   |
| 2.3 Maximum Application Based on 2xPhosphorus Removal.....  | 5   |
| 2.4 Maximum Application Based on 1x Phosphorus Removal .....  | 9   |
| 2.5 The Change in Total Manure Application Costs.....   | 12  |
| 2.6 Total Manure Application Cost Increase to Industry due to<br>proposed Phosphorus Regulations..... | 12  |
| <b>3.0 APPLYING THE FRAMEWORK TO THE MANITOBA PIG INDUSTRY.....</b>                                   | <b>13</b>   |
| 3.1 Data used to Model the Manitoba Pig Industry .....  | 13  |
| 3.2 Calculation of Model Constants.....   | 14  |
| 3.3 Model Assumptions.....  | 14  |
| <b>4.0 RESULTS AND DISCUSSION.....</b>  | <b>16</b>   |
| <b>APPENDICIES</b>  |   |
| APPENDIX A  | NURRIENT REMOVAL AND LAND AVAILABILITY INDEX<br>BY RURAL MUNICIPALITY |
| APPENDIX B  | RESULTS FOR A STANDARD SIZE OPERATION IN<br>MANITOBA                  |

## LIST OF TABLES

|         |   |    |
|---------|---|----|
| Table 1 | Total manure produced per day for five different types of pig operations.....   | 3  |
| Table 2 | Operation classification.....   | 7  |
| Table 3 | Operation type descriptions and conversions from animal units to no. head.....  | 13 |
| Table 4 | Values for cost constants $C_i$ for the province of Manitoba.....   | 14 |
| Table 5 | The R.M.s with the largest added annual cost for compliance to the maximum threshold regulations of 2xP and 1xP removal.....                                  | 17 |
| Table 6 | Percentage of operations being classified as each of the four cases – enough land, truck surplus up to 20 km, truck surplus up to 40 km and treat manure..... | 17 |

## LIST OF FIGURES

|          |   |    |
|----------|---|----|
| Figure 1 | General framework for minimum land requirements and cost assessment.....  | 2  |
| Figure 2 | Electronic rings around individual farm locations (The N-based land area is that which lies within the electronic ring).....  | 5  |
| Figure 3 | Electronic ring around individual farm locations (The 2xP land area is that which lies within the outer electronic ring)..... | 7  |
| Figure 4 | Electronic ring around individual farm locations (The 1xP land area is that which lies within the outer electronic ring)..... | 10 |

## **INTRODUCTION<sup>1</sup>**

New manure phosphorus regulations for pig producers in Manitoba have been proposed. To comply with the proposed regulations, producers will be required to make changes in their managing of pig manure. These changes will come at some cost.

Part 1 (Salvano et al 2006<sup>2</sup>) of this study has outlined the proposed new phosphorus regulations as well as the framework for analysis of related changed manure management costs. It has also assigned unit costs to each of the alternative activities involved. Part 2 (this part) applies the framework to the Manitoba pig industry to determine an estimated additional annual cost to the industry for compliance to the soil test phosphorus thresholds. The other provisions of the regulation are not addressed<sup>3</sup>.

### **1. OBJECTIVE**

The objective of this part of the study (Part 2) is to estimate the effect proposed phosphorus regulations in Manitoba will have on manure management costs to the Province's pig producers (individually and in aggregate), should the regulations come into effect. The task is to apply the framework for analysis outlined in Part 1 to determine an estimated annual Provincial cost.

### **2. METHOD**

To establish an aggregate estimate of changed manure management costs requires first a determination of the estimated cost at the individual operation or farm level. The individual costs can then be aggregated to determine an estimate at the Provincial level.

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<sup>1</sup> I would like to acknowledge the following for their important contributions to this report: Mr. Jeff Clark (Manitoba Pork Council), Mr. Scott Dick (Elite Swine), Dr. Don Flaten (University of Manitoba), Mr. Gary Plohman (MAFRI), Dr. Ester Salvano (MAFRI) and Mr. Marc Trudelle (Manitoba Conservation).

<sup>2</sup> Salvano, E., D. Flaten, C. Grant and G. Johnson. 2006. Economic assessment of manure phosphorus regulations for Manitoba's pig industry. University of Manitoba.

<sup>3</sup> Refer to section 2 of Part 1 for a detailed description of new proposed environmental regulations

For the individual operation, the cost estimation is a three-step process: first, establish a N-based cost and land area (cost and land area that relates to standard nitrogen-based application<sup>4</sup>); second, establish the cost and land area required under compliance to the new regulations; third, subtract the second estimates from the first to determine the changes.

Figure 1 illustrates the method of calculation. The N-based, 2xP<sup>5</sup> and 1xP (changed scenarios) land area requirements are calculated for each pig operation in Manitoba. Each operation is then classified as either having enough land (enough now or ready access to additional adjacent land), or not having enough land to comply with the new phosphorus regulations. For those operations with sufficient land, the additional costs associated with spreading over a larger area are calculated. For those operations with insufficient land, the least-cost means for dealing with the regulation is applied – either transport manure or treat manure. The change in costs between N-based and both the 2xP and 1xP scenarios are calculated. The per-farm changed costs are then aggregated to find the total change in manure management costs for Manitoba pig producers under each level of the proposed new regulations.

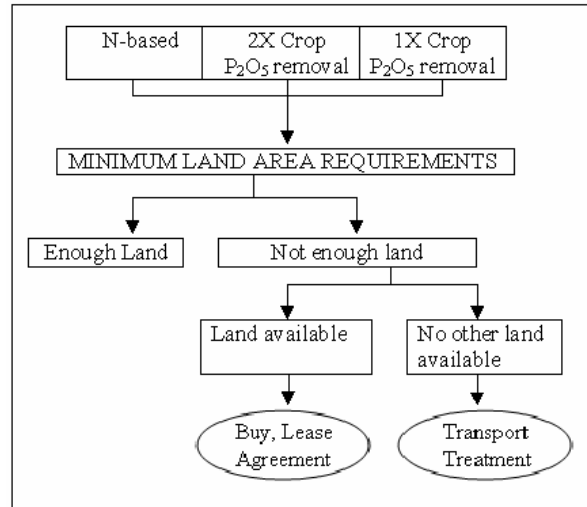


Figure 1: General framework for minimum land requirements and cost assessment (Salvano et al)<sup>6</sup>

<sup>4</sup> Pig operations are currently managing their manure applications on a nitrogen basis. It is taken that all operations in Manitoba have a sufficient land base for standard nitrogen-based application since earlier manure management plans have been established on that basis. For this study nitrogen-based application is labelled the N-based scenario.

<sup>5</sup> For simplicity in nomenclature, P<sub>2</sub>O<sub>5</sub> is denoted as P throughout this Part 2 report.

<sup>6</sup> Source: Adapted from Salvano et al 2006 Part 1 Figure 3.1 – General framework for minimum land requirements and cost assessment.

## 2.1 Total Manure Produced

The total volume of manure produced by a pig operation is a function of operation type and size. The manure production per day for five operation types is given in Table 1. These numbers are averages for pig farmers in Manitoba assuming phytase is being used.

Table 1 – Total volume of manure produced per day for five different types of pig operations<sup>7</sup>

| <i>Operation Type</i>   | <i>Description</i> | <i>Manure Produced</i> | <i>Units</i>   |
|-------------------------|--------------------|------------------------|----------------|
| Sow, Farrow to Nursery  | 0 kg – 5.4 kg      | 23                     | L/sow/day      |
| Sow, Farrow to Weanling | 0 kg – 21 kg       | 23                     | L/sow/day      |
| Sow, Farrow to Finish   | 0 kg – 108+ kg     | 63                     | L/sow/day      |
| Weanling                | 5.4 kg – 21 kg     | 2.3                    | L/weanling/day |
| Finisher                | 21 kg – 108+ kg    | 7.1                    | L/finisher/day |

Using the manure production values in Table 1, total volume of manure produced in imperial gallons for operation *i* in a single year is calculated with equation 1.

$$[1] \text{Total Manure}_i \text{ (imp gal)} = (\chi_{i1} \times 23 + \chi_{i2} \times 23 + \chi_{i3} \times 63 + \chi_{i4} \times 2.3 + \chi_{i5} \times 7.1) \times 365 \times 0.219$$

- $\chi_{i1}$  – Number of sows, farrow to nursery in operation *i*
- $\chi_{i2}$  – Number of sows, farrow to weanling in operation *i*
- $\chi_{i3}$  – Number of sows, farrow to finish in operation *i*
- $\chi_{i4}$  – Number of weanlings in operation *i*
- $\chi_{i5}$  – Number of finishers in operation *i*
- 365 – Days in a year
- 0.219 – Conversion from Liters to imperial Gallons

<sup>7</sup>Source: Scott Dick (Elite Swine), personal communication.

## 2.2 Maximum Application Based on Nitrogen Removal

N-based land area is a function of nitrogen removal rate, operation type and size. The N-based area for operation  $i$  is calculated with equation 2<sup>8</sup>.

$$[2] N - Based \ land \ area_i \ (ac) = 2.2 \times 0.5 \times \left( \frac{\chi_{i1} \times 1 \times 18 + \chi_{i2} \times 1 \times 19.5 + \chi_{i3} \times 1 \times 34.6 + \chi_{i4} \times 6.4 \times 0.226 + \chi_{i5} \times 2.9 \times 2.69}{NR_i \times LA_i} \right)$$

- $NR_i$  – Nitrogen removal rate (lbs/ac) at location  $i$
- $LA_i$  – Land availability index at location  $i$

The nitrogen removal rate ( $NR_i$ ) is a function of soil type and crop type. A unique  $NR_i$  has been calculated for each of the 25 largest pig producing municipalities in Manitoba, each with their own mix of annual crops, forages, and grasslands. The  $NR_i$  are listed in Table A1 of Appendix A and are calculated using information from *Soils and terrain: An introduction to the land resource*<sup>9</sup>. For all other rural municipalities in Manitoba, a standard  $NR_i$  of 70 pounds per acre<sup>10</sup> is used.

The land availability index ( $LA_i$ ) is a function of annual crop land, forage land, grasslands, trees, wetlands, water, urbanization, and competition for land from other livestock operations. The  $LA_i$  increases the area of land required to spread manure to account for land not able to receive manure (trees, wetlands, water, urbanization, and competition from other livestock operations). For example, operations located in a R.M. with a  $LA_i$  of 1.5 would require 150 acres in total to have access to 100 acres for manure application. A unique  $LA_i$  has been calculated for each of the 25 largest pig producing municipalities in Manitoba based on *Soils and terrain: An introduction to the land resources*<sup>11</sup> and *Acceptable phosphorus concentrations in soils and impact on the risk of phosphorus transfer from manure amended soils to surface waters* and are

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<sup>8</sup> Source: Equation extracted from Manitoba Conservation Excel Sheet – Forwarded by Mr. Gary Plohman (MAFRI).

<sup>9</sup> Source: Fraser, W., P. Cyr, G. Eilers and G. Lelyk. 2001. *Soils and terrain: An introduction to the land resource*. Agriculture and Agri-Food Canada.

<sup>10</sup> Source: Manitoba Conservation Excel Sheet – Forwarded by Mr. Gary Plohman (MAFRI).

<sup>11</sup> Source: Fraser et al 2001

listed in Table A1 of Appendix A.<sup>12,13</sup> For all other rural municipalities in Manitoba, a standard LA<sub>i</sub> of 1 is used.

N-based manure application cost is a function of total manure (in imperial gallons) and cost of spreading manure. The N-based cost is calculated with equation 3.

$$[3] N - Based \ cost_i (\$) = Total \ Manure_i (imp \ gal) \times C_1$$

- C<sub>1</sub> – Cost per imperial gallon to spread manure on N-based land area<sup>14</sup>

Using GIS computer software an electronic ring can be drawn around individual farms to show the area required for manure application. Figure 2 shows the area required for the N-based applications.

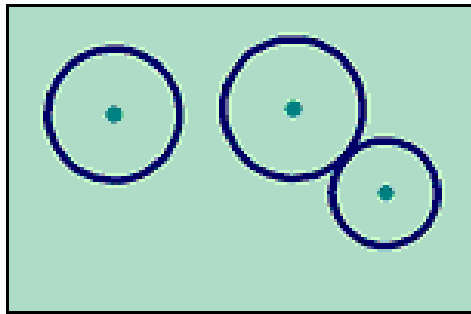


Figure 2: Electronic rings around individual farm locations  
(The N-based land area is that which lies within the electronic ring)

### 2.3 Maximum Application Based on 2xPhosphorus Removal

One proposed threshold for the new phosphorus regulations is that phosphorus applications not exceed two-times the phosphorus removal rate. If the new regulation is mandated at that level, both the area and cost of manure management will change from the existing N-based level.

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<sup>12</sup> Flaten, D., K. Snelgrove, I. Halket, K. Buckley, G. Penn, W. Akinremi, B. Wiebe and E. Tyrchniewicz. 2003. Acceptable phosphorus concentrations in soils and impact on the risk of phosphorus transfer from manure amended soils to surface waters. University of Manitoba and AAFC Brandon Research Center.

<sup>13</sup> Source: Dr. Don Flaten (University of Manitoba), personal communication.

<sup>14</sup> Values for all constants (C<sub>i</sub>) are taken from Part 1 and are listed in section 3.2.

The area of land required to apply total manure produced at a rate up to twice the phosphorus removal is a function of phosphorus removal rate, operation type and size. The total area of land required is calculated using equation 4<sup>15</sup>.

$$[4] 2 \times P \text{ land area}_i (\text{ac}) = 2.2 \times \left( \begin{array}{l} x_{i1} \times 1 \times 12.3 + x_{i2} \times 1 \times 13.3 + x_{i3} \times 1 \times 21.5 + \\ x_{i4} \times 6.4 \times 0.117 + x_{i5} \times 2.9 \times 1.47 \end{array} \right) \div (2 \times PR_i) \times LA_i$$

- $PR_i$  – Phosphorus removal rate (lbs/ac) at location i
- $LA_i$  – Land availability index at location i

Phosphorus removal rate ( $PR_i$ ), like the nitrogen removal rate ( $NR_i$ ), is a function of soil type and crop type. A unique  $PR_i$  has been calculated for each of the 25 largest pig producing municipalities in Manitoba, each with their own mix of annual crops, forages, and grasslands. The  $PR_i$  are listed in Table A1 of Appendix A and are calculated using information from *Soils and terrain: An introduction to the land resource*<sup>16</sup>. For all other rural municipalities in Manitoba, a standard  $PR_i$  of 30 pounds per acre<sup>17</sup> is used. The land availability index ( $LA_i$ ) is the same as described in the previous section and remains the same throughout the remainder of the study.

Using the 2xP land area in acres each operation i is classified into one of two categories – having enough land or not having enough land. There are three options for operations that are classified into the second category:

- Truck surplus manure up to 20 kilometers
- Truck surplus manure up to 40 kilometers
- Treat the manure to remove phosphorus and then spread it on existing land

The two scenarios and three options leave four mutually exclusive and exhaustive cases, listed in Table 2.

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<sup>15</sup> Source: Equation extracted from Manitoba Conservation Excel Sheet – Forwarded by Mr. Gary Plohman (MAFRI).

<sup>16</sup> Source: Fraser et al 2001

<sup>17</sup> Source: Manitoba Conservation Excel Sheet – Forwarded by Mr. Gary Plohman (MAFRI).

Table 2: Operation classification

|        | <i>Scenario</i> | <i>Option</i>                |
|--------|-----------------|------------------------------|
| Case 1 | Enough land     | N/A                          |
| Case 2 | Not enough land | A. Truck surplus up to 20 km |
| Case 3 | Not enough land | B. Truck surplus up to 40 km |
| Case 4 | Not enough land | C. Treat manure              |

This leaves the decision to be made for each operation  $i$  as to which classification it receives. A GIS program is used to map the 2xP land area <sub>$i$</sub>  for each location by placing an electronic ring around the barn encompassing the area calculated using equation 4. An illustrative example is shown in Figure 3. By assessing the GIS map and the electronic ring created around each operation, each operation  $i$  is classified as one of the four cases according to the following procedure:

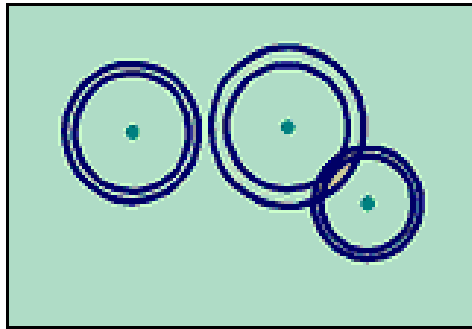


Figure 3: Electronic rings around individual farm locations  
(The 2xP land area is that which lies within the outer electronic ring)

### Case 1: Enough Land

If the electronic ring around operation  $i$  is not overlapped by any other operation's electronic ring, the operation is classified as Case 1. The manure management cost can be calculated by equation 5 and is denoted as  $2xP TC_{i1}$ .

$$[5] 2 \times P TC_{i1} (\$) = \frac{N - Based\ land\ area_i}{2xP\ land\ area_i} \times Total\ Manure_i \times C_1 + \left( 1 - \frac{N - Based\ land\ area_i}{2xP\ land\ area_i} \right) \times Total\ Manure_i \times C_2$$

- $C_1$  – Cost per imperial gallon to spread manure on N-based land area
- $C_2$  – Cost per imperial gallon to spread manure on land beyond N-based land area

### Case 2: Not Enough Land – Truck Surplus up to 20 km

If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by less than 25 percent, the operation is classified as Case 2. The manure management cost is calculated with equation 6 and is denoted as  $2xP TC_{i2}$ .

$$[6] 2 \times P TC_{i2} (\$) = \frac{N - \text{Based land area}_i}{2xP \text{ land area}_i} \times \text{Total Manure}_i \times C_1 + \left( 1 - \frac{N - \text{Based land area}_i}{2xP \text{ land area}_i} \right) \times \text{Total Manure}_i \times C_2 + \text{Percent Overlap}_i \times \text{Total Manure}_i \times C_3$$

- $C_1$  – Cost per imperial gallon to spread manure on N-based land area
- $C_2$  – Cost per imperial gallon to spread manure on land beyond N-based land area
- $C_3$  – Cost per imperial gallon to transport manure up to 20 kilometers

### Case 3: Not Enough Land – Truck Surplus up to 40 km

If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by less than 25 percent and the operation is located in La Broquerie, De Salaberry or Hanover<sup>18</sup>, the operation is classified as Case 3. The manure management cost is calculated with equation 7 and is denoted as  $2xP TC_{i3}$ .

$$[7] 2 \times P TC_{i3} (\$) = \frac{N - \text{Based land area}_i}{2xP \text{ land area}_i} \times \text{Total Manure}_i \times C_1 + \left( 1 - \frac{N - \text{Based land area}_i}{2xP \text{ land area}_i} \right) \times \text{Total Manure}_i \times C_2 + \text{Percent Overlap}_i \times \text{Total Manure}_i \times C_4$$

- $C_1$  – Cost per imperial gallon to spread manure on N-based land area
- $C_2$  – Cost per imperial gallon to spread manure on land beyond N-based land area
- $C_4$  – Cost per imperial gallon to transport manure up to 40 kilometers

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<sup>18</sup> The concentration of livestock operations in these RM's together with more-limited land availability creates a condition where their producers are forced to truck surplus manure further than would be the case in other Manitoba R.M.'s, hence the special treatment.

### Case 4: Not Enough Land – Treat Manure

If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by more than 25 percent it is classified as Case 4. The manure management cost is calculated with equation 8 and is denoted as  $2xP TC_{i4}$ .

$$[8] 2xP TC_{i4}(\$) = \text{Base-level } TC_1 + \text{Total Manure } \xi \times C_5 + C_6$$

- $C_5$  – Cost per imperial gallon to treat manure
- $C_6$  – Fixed cost per year for treatment system

### 2.4 Maximum Application Based on 1x Phosphorus Removal

A second proposed threshold for the new phosphorus regulations is that phosphorus applications be limited to one-times the phosphorus removal rate. If the new regulation is mandated at this level, both the area and cost of manure management will change from the existing N-based and 2xPhosphorus removal levels.

The first step is to determine the area of land required to spread the total amount of manure produced per operation according to a maximum application rate equal to one-times phosphorus removal. The calculation is made with equation 9<sup>19</sup>.

$$[9] 1 \times P \text{ land area}_i (ac) = 2.2 \times \left( \frac{\chi_{i1} \times 1 \times 12.3 + \chi_{i2} \times 1 \times 13.3 + \chi_{i3} \times 1 \times 21.5 +}{\chi_{i4} \times 6.4 \times 0.117 + \chi_{i5} \times 2.9 \times 1.47} \right) \div PR_i \times LA_i$$

- $PR_i$  – Phosphorus removal rate (lbs/ac) at location  $i$
- $LA_i$  – Land availability index at location  $i$

Equation 10 follows the simplification of equation 9.

$$[10] 1 \times P \text{ land area}_i (ac) = 2 \times P \text{ land area}_i \times 2$$

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<sup>19</sup> Source: Equation extracted from Conservation Excel Sheet – Forwarded by Mr. Gary Plohman (MAFRI).

The 1xP land area is then used to classify each operation  $i$  into one of the three cases outlined in Table 2 of section 2. The categorization of each operation  $i$  is made according to the same procedure as in section 2. The GIS program is used to map the 1xP land area <sub>$i$</sub>  for each operation by placing an electronic ring around the barn encompassing the desired area. An illustrative example is shown in Figure 4. By analyzing the GIS map, each operation  $i$  is classified according to the following procedure:

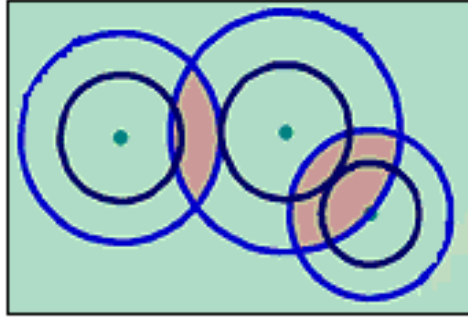


Figure 4: Electronic rings around individual farm locations  
(The 1xP land area is that which lies within the outer electronic ring)

### Case 1: Enough Land

If the electronic-ring around operation  $i$  is not overlapped by any other operation's electronic ring, the operation is classified as Case 1. The manure disposal cost can be calculated by equation 11 and is denoted as 1xP  $TC_{i1}$ .

$$[11] 1 \times P TC_{i1} (\$) = \frac{N - \text{Based land area}_i}{1xP \text{ land area}_i} \times \text{Total Manure}_i \times C_1 + \left( 1 - \frac{N - \text{Based land area}_i}{1xP \text{ land area}_i} \right) \times \text{Total Manure}_i \times C_2$$

- $C_1$  – Cost per imperial gallon to spread manure on N-based land area
- $C_2$  – Cost per imperial gallon to spread manure on land beyond N-based land area

### Case 2: Not Enough Land – Truck Surplus up to 20 km

If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by less than 25 percent, the operation is classified as Case 2. The manure management cost is calculated with equation 12 and is denoted as 1xP  $TC_{i2}$ .

$$[12] 1 \times P TC_{i2} (\$) = \frac{N - \text{Based land area}_i}{1 \times P \text{ land area}_i} \times \text{Total Manure}_i \times C_1 + \left( 1 - \frac{N - \text{Based land area}_i}{1 \times P \text{ land area}_i} \right) \times \text{Total Manure}_i \times C_2 + \text{Percent Overlap}_i \times \text{Total Manure}_i \times C_3$$

- $C_1$  – Cost per imperial gallon to spread manure on N-based land area
- $C_2$  – Cost per imperial gallon to spread manure on land beyond N-based land area
- $C_3$  – Cost per imperial gallon to transport manure up to 20 kilometers

### **Case 3: Not Enough Land – Truck Surplus up to 40 km**

If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by less than 25 percent and the operation is located in La Broquerie, De Salaberry or Hanover<sup>20</sup>, the operation is classified as Case 3. The manure management cost is calculated with equation 13 and is denoted as  $1 \times P TC_{i3}$ .

$$[13] 1 \times P TC_{i3} (\$) = \frac{N - \text{Based land area}_i}{1 \times P \text{ land area}_i} \times \text{Total Manure}_i \times C_1 + \left( 1 - \frac{N - \text{Based land area}_i}{1 \times P \text{ land area}_i} \right) \times \text{Total Manure}_i \times C_2 + \text{Percent Overlap}_i \times \text{Total Manure}_i \times C_4$$

- $C_1$  – Cost per imperial gallon to spread manure on N-based land area
- $C_2$  – Cost per imperial gallon to spread manure on land beyond N-based land area
- $C_4$  – Cost per imperial gallon to transport manure up to 40 kilometers

### **Case 4: Not Enough Land – Treat Manure**

If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by more than 25 percent it is classified as Case 4. The manure management cost is calculated with equation 14 and is denoted as  $1 \times P TC_{i4}$ .

$$[14] 1 \times P TC_{i4} (\$) = N - \text{Based} TC_1 + \text{Total Manure}_i \times C_5 + C_6$$

- $C_5$  – Cost per imperial gallon to treat manure
- $C_6$  – Fixed cost per year for treatment system

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<sup>20</sup> The concentration of livestock operations in these RM's together with more-limited land availability creates a condition where their producers are forced to truck surplus manure further than would be the case in other Manitoba RM's, hence the special treatment.

## 2.5 The Change in Total Manure Application Costs

To find the increase in cost of manure management to an individual operation  $i$  due to the implementation of proposed phosphorus regulations, the steps outlined in sections 2.2 through to 2.4 are applied and subsequent calculations are made as follows:

Proposed Threshold 1: Manure can be applied up to a maximum of two-times the removal rate of phosphorus.

$$[15] \Delta 2 \times P TC_i (\$) = 2 \times P TC_i - N - Based TC_i$$

Proposed Threshold 2: Manure can be applied up to a maximum of one-times the removal rate of phosphorus.

$$[16] \Delta 1 \times P TC_i (\$) = 1 \times P TC_i - N - Based TC_i$$

## 2.6 Total Manure Application Cost Increase to Industry due to proposed Phosphorus Regulations

Given the individual operation costs determined with equations 15 and 16, the total cost of proposed phosphorus regulations to the total pig industry (an industry aggregate cost) is calculated with equations 17 and 18 that follow:

Proposed Threshold 1: Manure can be applied up to a maximum of two-times the removal rate of phosphorus.

$$[17] TC_A (\$) = \sum_{i=1}^n \Delta 2 \times P TC_i$$

Proposed Threshold 2: Manure can be applied up to a maximum of one-times the removal rate of phosphorus.

$$[18] TC_B (\$) = \sum_{i=1}^n \Delta 1 \times P TC_i$$

### 3.0 APPLYING THE FRAMEWORK TO THE MANITOBA PIG INDUSTRY

Data and constants for the Manitoba pig industry are described in section 3.1 and 3.2 respectively. Refer to Appendix B for an application of the outlined method used to estimate the change in manure management costs due to the proposed new regulations. The demonstration operation is an 8,000 pig space finisher operation located in the R.M. of De Salaberry. The assumptions of the model are outlined in section 3.3.

#### 3.1 Data used to Model the Manitoba Pig Industry

To calculate the cost of the proposed phosphorus regulations to the pig industry in Manitoba, data was obtained from the Manitoba Pork Council Premises Registration Form. There are approximately 1,000<sup>21</sup> operations in Manitoba, with 851 fully completed Premises Registration Forms submitted as of March 31, 2006. The 851 surveyed pig operations are assumed to be representative of the approximate 1000 pig operations in the Province.

Data is reported on the Premises Registration Form in animal units. Producers are asked to report the maximum capacity of their operation for each of the five facilities shown in Table 1. The animal units are converted to number of head in each class for use in modeling (Table 3).

Table 3 - Operation type descriptions and conversions from animal units to no. head

| <i>Operation Type</i>   | <i>Description</i> | <i>Conversion from Animal<br/>Units to No. Head</i> |
|-------------------------|--------------------|---|
| Sow, farrow to nursery  | 0 kg – 5.4 kg      | 0.25  |
| Sow, farrow to weanling | 0 kg – 21 kg       | 0.313   |
| Sow, farrow to finish   | 0 kg – 108+ kg     | 1.25  |
| Weanling                | 5.4 kg – 21 kg     | 0.033   |
| Finisher                | 21 kg – 108+ kg    | 0.143   |

<sup>21</sup> Source: Mr. Jeff Clark (Manitoba Pork Council).

### 3.2 Calculation of Model Constants

Cost figures are assigned to each of the six constants (represented as  $C_i$ ) in the model. The value of each constant depends on production practices as well as technology, land availability, and fuel prices. Salvano et al (2006) have calculated the cost constants for the province of Manitoba (refer to Part 1). These constants are used to find the total cost of complying with the regulations and are listed in Table 4.

Table 4: Values for cost constants  $C_i$  for the province of Manitoba

| <i>Constant</i> | <i>Description</i>  | <i>Value</i>              |
|-----------------|---|---------------------------|
| $C_1$           | Cost to spread manure over base-land area (per imperial gallon)       | \$0.009                   |
| $C_2$           | Cost to spread manure over land beyond N-based (per imperial gallon)  | \$0.011                   |
| $C_3$           | Cost of transporting manure up to 20 kilometers (per imperial gallon) | \$0.018                   |
| $C_4$           | Cost of transporting manure up to 40 kilometers (per imperial gallon) | \$0.037                   |
| $C_5$           | Cost of treating manure (per imperial gallon)                         | \$0.01 <sup>22</sup>      |
| $C_6$           | Fixed cost per year for treatment system <sup>23</sup>                |                           |
|                 | ▪ Less than 2,500,000 imperial gallons                                | \$55,000 <sup>24,25</sup> |
|                 | ▪ 2,500,000 to 5,000,000 imperial gallons                             | \$82,500                  |
|                 | ▪ More than 5,000,000 imperial gallons                                | \$140,037                 |

### 3.3 Model Assumptions

As with any economic model, there are a set of assumptions incorporated. These assumptions should be kept in mind when interpreting the final results. The assumptions include:

- I Sourced data are accurate and complete. Sourced data include:
- i. Manure production values listed in Table 1

<sup>22</sup> Source: Corporation HET: Horizon Environnement Technologies.

<sup>23</sup> Cost includes a basic LISOX system with concrete tanks (including the cost of electrical and process installation)

<sup>24</sup> Calculated with a 7.5% interest rate and straight-line depreciation over 10 years

<sup>25</sup> Source: Corporation HET: Horizon Environnement Technologies.

- ii. Manitoba Conservation Excel Sheet equations 2, 4, and 9
- iii. Manitoba Conservation Excel Sheet standard  $NR_i$  of 70 pounds per acre and  $PR_i$  of 30 pounds per acre
- iv. Values for nutrient removal and land availability index for the 25 largest pig producing rural municipalities in Manitoba listed in Table A1.
- v. Cost constant ( $C_i$ ) values for the Province of Manitoba listed in Table 4
- vi. Figures extracted from the Premises Registration Forms submitted by producers to the Manitoba Pork Council.
- vii. Total pig production and annual operating/capital costs from Manitoba Pig Industry Flow Chart

II Classification of manure management practices are representative of industry practices.

Classifications are listed as follows:

- i. If the electronic-ring around operation  $i$  is not overlapped by any other operation's electronic ring, the operation is classified as having enough land.
- ii. If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by less than 25 percent, the operation is classified as having to truck surplus manure up to 20 km.
- iii. If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by less than 25 percent and the operation is located in La Broquerie, De Salaberry or Hanover, the operation is classified as having to truck surplus manure up to 40 km.
- iv. If the electronic ring around operation  $i$  is overlapped by adjacent electronic rings by more than 25 percent it is classified as having to treat manure.

III The 851 surveyed pig operations are representative of the total of approximately 1000 pig operations in the Province.

IV All landowners in Manitoba are willing to have manure spread on their land.

## 4.0 Results and Discussion

New phosphorus regulations for pig producers in Manitoba have been proposed. To comply with the proposed regulations, producers will be required to make changes in their managing of pig manure. These changes will come at some cost.

Part 1 of this study (Salvano et al 2006) has outlined the proposed phosphorus regulations, namely the maximums of two-times the removal rate of phosphorus and one-times the removal rate of phosphorus. It also has outlined the framework for analysis of related changed manure management costs and has assigned unit costs to each of the alternative activities involved. Part 2 (this part) applies the framework to the Manitoba pig industry to determine an estimated additional annual cost to the industry for compliance to the proposed phosphorus regulations.

To establish an aggregate estimate of changed manure management costs requires first a determination of the estimated costs at the individual farm level. The individual costs across the province are then aggregated to determine an estimate at the Provincial level.

For the individual farm, the cost estimation is a three-step process: first, establish a N-based cost and land area (cost and land area that relates to standard nitrogen-based application); second, establish the cost and land area required under compliance to the new regulations; third, subtract the second estimates from the first to determine the changes. This process has been undertaken for each individual pig operation in Manitoba according to data submitted by producers under the Manitoba Pork Council Premises Registration Form. There are an estimated 1,000 operations in Manitoba, with 851 fully completed forms as of March 31, 2006.

The additional costs to individual operations have been estimated. These estimates have been aggregated to determine estimated added Provincial costs. The estimated added annual cost to the Manitoba pig industry under a maximum threshold regulation of 2xPhosphorus removal rate is 17.88 million dollars and the estimated added annual cost to the industry under a maximum threshold regulation of 1xPhosphorus removal rate regulation is 27.86 million dollars.

The added annual costs are not distributed evenly across the Province. The R.M. of Hanover faces the greatest added annual costs followed by La Broquerie, De Salaberry, Morris, and Ste. Anne, as listed in Table 5.

Table 5: The R.M.s with the largest added annual cost for compliance to the maximum threshold regulations of 2xP and 1xP removal

| <i>Rural Municipality</i> | $\Delta 1xP$ | $\Delta 2xP$ |
|---------------------------|--------------|--------------|
| Hanover                   | \$6,681,676  | \$4,861,749  |
| La Broquerie              | \$2,923,540  | \$2,000,757  |
| De Salaberry              | \$1,870,514  | \$1,344,176  |
| Morris                    | \$1,607,617  | \$1,049,53   |
| Ste. Anne                 | \$1,213,060  | \$ 860,522   |

The added annual costs are also not distributed evenly across all operations. Operations with enough land face less added costs than those that require trucking or treatment. Table 6 lists the percentages of operations falling into each of the four cases – enough land, truck up to 20 km, truck up to 40 km, and treat manure.

Table 6: Percentage of operations being classified as each of the four cases – enough land, truck surplus up to 20 km, truck surplus up to 40 km and treat manure

|                                   | <i>2 x Phosphorus Removal<br/>(Percent of Operations)</i> | <i>1 x Phosphorus Removal<br/>(Percent of Operations)</i> |
|-----------------------------------|---|---|
| Case 1: Enough land               | 68.86%  | 56.87%  |
| Case 2: Truck surplus up to 20 km | 6.93%   | 9.75%   |
| Case 3: Truck surplus up to 40 km | 5.99%   | 4.58%   |
| Case 4: Treat manure              | 18.21%  | 28.79%  |

The estimated added annual cost to the Manitoba pig industry under a maximum threshold regulation of 2xPhosphorus removal of 17.88 million dollars represents about 18% of the estimated annual 2005 net income<sup>26,27</sup> accruing to pig producers in the Province. The estimated added annual cost under a maximum threshold regulation of 1xPhosphorus removal of 27.86 million dollars represents about 28% of the estimated annual 2005 net income<sup>28</sup> accruing the pig producers in the province.

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<sup>26</sup> Source: Honey, Janet. September, 2006. Manitoba pig industry flow chart, 2005.

<sup>27</sup> The net income accruing to Manitoba pig producers in 2005 is estimated at 100 million dollars (value of pigs produced of 1,020 million dollars less operating and capital costs of 920 million dollars)

<sup>28</sup> Source: Honey, Janet. September, 2006. Manitoba pig industry flow chart, 2005.

**APPENDIX A**  
**NUTRIENT REMOVAL AND LAND AVAILABILITY**  
**INDEX BY RURAL MUNICIPALITY**

Table A1 Nutrient Removal and Land Availability Index by Rural Municipality<sup>29</sup>

| <i>Rural Municipality</i> | <i>Nitrogen Removal<br/>(lbs/ac)</i> | <i>Phosphorus (P<sub>2</sub>O<sub>5</sub>)<br/>Removal (lbs/ac)</i> | <i>Land Availability<br/>Index</i> |
|---------------------------|--------------------------------------|---|------------------------------------|
| Bifrost                   | 65.0                                 | 25.0  | 1.49                               |
| Cartier                   | 69.3                                 | 29.3  | 1.17                               |
| De Salaberry              | 67.7                                 | 27.7  | 1.22                               |
| Dufferin                  | 68.4                                 | 28.4  | 1.22                               |
| Fisher                    | 63.1                                 | 23.1  | 1.49                               |
| Franklin                  | 66.1                                 | 26.1  | 1.25                               |
| Grandview                 | 66.7                                 | 26.7  | 1.51                               |
| Hanover                   | 64.6                                 | 24.6  | 1.30                               |
| La Broquerie              | 59.4                                 | 19.4  | 1.44                               |
| Lorne                     | 67.7                                 | 27.7  | 1.25                               |
| Morris                    | 69.4                                 | 29.4  | 1.15                               |
| North Norfolk             | 64.7                                 | 24.7  | 1.02                               |
| Pembina                   | 68.0                                 | 28.0  | 1.30                               |
| Portage                   | 62.5                                 | 22.5  | 1.15                               |
| Ritchot                   | 68.3                                 | 28.3  | 1.17                               |
| Roblin                    | 67.2                                 | 27.2  | 1.26                               |
| Rockwood                  | 65.8                                 | 25.8  | 1.34                               |
| Rosedale                  | 64.4                                 | 24.4  | 1.46                               |
| South Norfolk             | 67.2                                 | 27.2  | 1.33                               |
| Stanley                   | 68.4                                 | 28.4  | 1.24                               |
| Ste. Anne                 | 64.5                                 | 24.5  | 1.54                               |
| Stuartburn                | 59.3                                 | 19.3  | 1.60                               |
| Tache                     | 66.9                                 | 26.9  | 1.31                               |
| Turtle Mountain           | 67.1                                 | 27.1  | 1.25                               |
| Whitemouth                | 66.5                                 | 26.4  | 1.79                               |

<sup>29</sup> Source: Fraser, W., P. Cyr, G. Eilers and G. Lelyk. 2001. Soils and terrain: An introduction to the land resource. Agriculture and Agri-Food Canada.

**APPENDIX B**  
**RESULTS FOR A STANDARD SIZE OPERATION**  
**IN MANITOBA**

## RESULTS FOR A STANDARD SIZE OPERATION IN MANITOBA

A finishing barn with 8,000 pig spaces is used to demonstrate the outlined method used to estimate the change in manure management costs due to the proposed new regulations. The demonstration operation is assumed to be located in the Rural Municipality of De Salaberry and will be referred to as Operation A. For equations 1 through 16 the original equation is presented, followed by the equation for Operation A and the result.

### Maximum Application Based on Nitrogen Removal

$$[1] \text{Total Manure}_A (\text{imp gal}) = (\chi_{A1} \times 23 + \chi_{A2} \times 23 + \chi_{A3} \times 63 + \chi_{A4} \times 2.3 + \chi_{A5} \times 7.1) \times 365 \times 0.219$$

- $0 = \chi_{i1}$  – Number of sows, farrow to nursery in operation A
- $0 = \chi_{i2}$  – Number of sows, farrow to weanling in operation A
- $0 = \chi_{i3}$  – Number of sows, farrow to finish in operation A
- $0 = \chi_{i4}$  – Number of weanlings in operation A
- $8000 = \chi_{i5}$  – Number of finishers in operation A
- 365 – Days in a year
- 0.219 – Conversion from Liters to imperial Gallons

$$[1] \text{Total Manure}_A (\text{imp gal}) = (0 \times 23 + 0 \times 23 + 0 \times 63 + 0 \times 2.3 + 8000 \times 7.1) \times 365 \times 0.219$$

$$[1] \text{Total Manure}_A (\text{imp gal}) = 4,540,308$$

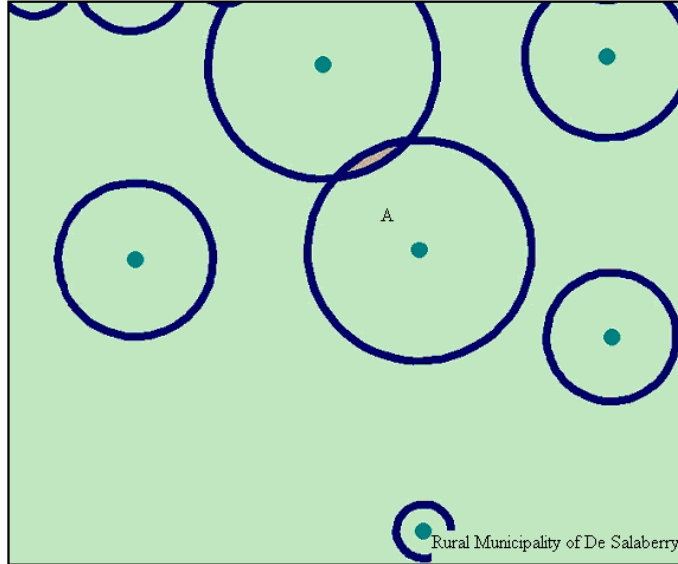


Figure B1: Location and nitrogen electronic ring around Operation A

### Maximum Application Based on 2xPhosphorus Removal

$$[2] \text{ N - Based land area }_A \text{ (ac)} = 2.2 \times 0.5 \times \left( \frac{\chi_{A1} \times 1 \times 18 + \chi_{A2} \times 1 \times 19.5 + \chi_{A3} \times 1 \times 34.6 +}{\chi_{A4} \times 6.4 \times 0.226 + \chi_{A5} \times 2.9 \times 2.69} \right) \div NR_A \times LA_A$$

- 67.7 =  $NR_A$  – Nitrogen removal rate (lbs/ac) at location A
- 1.22 =  $LA_A$  – Land availability index at location A

$$[2] \text{ N - Based land area }_A \text{ (ac)} = 2.2 \times 0.5 \times \left( \frac{0 \times 1 \times 18 + 0 \times 1 \times 19.5 + 0 \times 1 \times 34.6 +}{0 \times 6.4 \times 0.226 + 8000 \times 2.9 \times 2.69} \right) \div 67.7 \times 1.22$$

$$[2] \text{ N - Based land area }_A = 1,237.10$$

$$[3] \text{ N - Based cost }_A \text{ (\$)} = \text{Total Manure}_A \text{ (imp gal)} \times C_1$$

- 0.009 =  $C_1$  – Cost per imperial gallon to spread manure on N-based land area

$$[3] \text{ N - Based cost }_A \text{ (\$)} = 4,540,308 \times 0.009$$

$$[3] \text{ N - Based cost }_A \text{ (\$)} = 40,862.77$$

$$[4] 2 \times P \text{ land area}_A (\text{ac}) = 2.2 \times \left( \frac{\chi_{A1} \times 1 \times 12.3 + \chi_{A2} \times 1 \times 13.3 + \chi_{A3} \times 1 \times 21.5 + \chi_{A4} \times 6.4 \times 0.117 + \chi_{A5} \times 2.9 \times 1.47}{\chi_{A4} \times 6.4 \times 0.117 + \chi_{A5} \times 2.9 \times 1.47} \right) \div (2 \times PR_A) \times LA_A$$

- 27.7 =  $PR_A$  – Phosphorus removal rate (lbs/ac) at location A
- 1.22 =  $LA_A$  – Land availability index at location A

$$[4] 2 \times P \text{ land area}_A (\text{ac}) = 2.2 \times \left( \frac{0 \times 1 \times 12.3 + 0 \times 1 \times 13.3 + 0 \times 1 \times 21.5 + 0 \times 6.4 \times 0.117 + 8000 \times 2.9 \times 1.47}{0 \times 6.4 \times 0.117 + 8000 \times 2.9 \times 1.47} \right) \div (2 \times 27.7) \times 1.22$$

$$[4] 2 \times P \text{ land area}_A (\text{ac}) = 1,652.26$$

Using Figure 6 below, Operation A is classified as one of the four cases described in Table 2. The electronic ring around Operation A overlaps with another operation's electronic ring by 13.5 percent (less than 25 percent) and is located in De Salaberry. These two facts allow Operation A to be classified as Case 3. The manure management cost is calculated with equation 7.

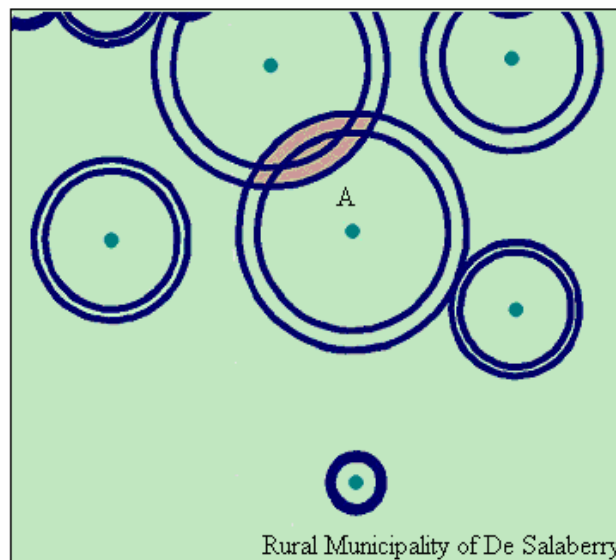


Figure B2: 2xP electronic ring around barn location of Operation A  
(The 2xP land area is that which lies within the outer electronic ring)

$$[7] 2 \times P TC_{A3} (\$) = \frac{N - Bssed\ land\ area_A}{2 \times P\ land\ area_A} \times Total\ Manure_A \times C_1 + \left( 1 - \frac{N - Basedl\ land\ area_A}{2 \times P\ land\ area_A} \right) \\ \times Total\ Manure_A \times C_2 + Percent\ Overlap_A \times Total\ Manure_A \times C_4$$

- \$0.009 = C<sub>1</sub> – Cost per imperial gallon to spread manure on N-based land area
- \$0.011 = C<sub>2</sub> – Cost per imperial gallon to spread manure on land beyond N-based
- \$0.037 = C<sub>4</sub> – Cost per imperial gallon to transport manure up to 40 kilometers

$$[7] 2 \times P TC_{A3} (\$) = \frac{1,237.10}{1,652.26} \times 4,540,308 \times 0.009 + \left( 1 - \frac{1,237.10}{1,652.26} \right) \\ \times 4,540,308 \times 0.011 + 0.135 \times 4,540,308 \times 0.037$$

$$[7] 2 \times P TC_{A3} (\$) = 65,823.28$$

### Maximum Application Based on 1x Phosphorus Removal

$$[9] 1 \times P\ land\ area_A (ac) = 2.2 \times \left( \frac{\chi_{A1} \times 1 \times 12.3 + \chi_{A2} \times 1 \times 13.3 + \chi_{A3} \times 1 \times 21.5 +}{\chi_{A4} \times 6.4 \times 0.117 + x_{A5} \times 2.9 \times 1.47} \right) \div PR_A \times LA_A$$

- 27.7 = PR<sub>A</sub> – Phosphorus removal rate (lbs/ac) at location A
- 1.22 = LA<sub>A</sub> – Land availability index at location A

$$[9] 1 \times P\ land\ area_A (ac) = 2.2 \times \left( \frac{0 \times 1 \times 12.3 + 0 \times 1 \times 13.3 + 0 \times 1 \times 21.5 +}{0 \times 6.4 \times 0.117 + 8000 \times 2.9 \times 1.47} \right) \div 27.7 \times 1.22$$

$$[9] 1 \times P\ land\ area_A (ac) = 3,304.52$$



Figure B3: 1xP electronic ring around barn location of Operation A  
(The 1xP land area is that which lies within the outer electronic ring)

Using Figure 6 above, Operation A is classified as one of the four cases described in Table 2. The electronic ring around Operation A overlaps with the electronic ring of four adjacent operations totaling more than 25 percent. Operation A is classified as Case 4 and the manure management costs can be calculated using equation 14.

$$[14] 1xPTC_A(\$) = \text{Base-level}TC_A + \text{TotalManure}_A \times C_5 + C_6$$

- \$0.01 =  $C_5$  – Cost per imperial gallon to treat manure
- \$82,500 =  $C_6$  – Fixed cost per year for treatment system

$$[14] 1xPTC_A(\$) = 40,862.77 + 4,540,308 \times 0.01 + 82,500$$

$$[14] 1xPTC_A(\$) = 168,765.85$$

### The Change in Total Manure Application Costs

Proposed Threshold 1: Manure can be applied to a maximum of two-times the removal rate of phosphorus.

$$[15] \Delta 2 \times P TC_A (\$) = 2 \times P TC_A - N - Based TC_A$$

$$[15] \Delta 2 \times P TC_A (\$) = 65,823.28 - 40,862.77$$

$$[15] \Delta 2 \times P TC_A (\$) = 24,960.51$$

Proposed Threshold 2: Manure can be applied to a maximum of one-times the removal rate of phosphorus.

$$[16] \Delta 1 \times P TC_A (\$) = 1 \times P TC_A - N - Based TC_A$$

$$[16] \Delta 1 \times P TC_A (\$) = 168,765.85 - 40,862.77$$

$$[16] \Delta 1 \times P TC_A (\$) = 127,903.08$$