Optimizing Manure Removal in Two-cell Manure Storage Systems

Title: MLMMI 2015-07 "Optimizing Manure Removal from 2-Cell Manure Storage Systems"

Project Leader: Agra-Gold Consulting Ltd. (Cliff Loewen, Scott Dick)

Project Duration: August 2015 – August 2016

Executive Summary:

Since the Manitoba Livestock Manure and Mortalities Regulation 42/98 was updated in 2006 to include phosphorus limits, a number of producers are required to consider the phosphorus accumulation in their soil and thus apply their livestock nutrients over a greater number of acres. Applying manure phosphorus further and further away from the livestock operation has increased the costs associated with pumping, application and transportation. If a livestock producer is in a position of limited land base due to high soil test P fields and if the 2 cell EMS treatment system (using gravity to separate) can achieve the phosphorus segregation desired, alternative and more costly treatment forms may be avoided or postponed for a number of years.

The 2-cell earthen manure storage (EMS), with gravitational settling of the solids portion in primary cell, has historically provided a good solution for solids removal during manure application. Different pump out strategies of these type of storages can be used as a tool to segregate phosphorus based on environmental and/or crop requirements. This project quantifies the nutrient profile throughout the pump out based on different pump out techniques.

For this project two different sites in Southeastern Manitoba were chosen to investigate three different pump out strategies. These sites are both similar size multi-barn hog finishing sites with similar 2 cell manure storages, located in southeastern Manitoba. Numerous manure samples were taken to quantify dry matter and nutrient levels in the two-cell EMS's and characterize how the solids and nutrient concentrations change throughout the pump-out based on three selected pump-out strategies.

The first strategy analyzed was the common historical method in which some of the secondary manure is bled back into the primary cell during the pump out to assist in removing solids. The primary cell was agitated and pumped and once it was 60-75 % emptied, then a limited amount of secondary liquid manure was flushed back into the primary to re-suspend the solids to create a more homogenous product. Once the primary was as empty as necessary, the pump was moved over into the secondary cell to finish the pump out. During the first 46.9% portion of the primary/secondary mix pump, 94.9% of the total P205 was removed. This whole pump out was done by a drag hose pumping company.

If a livestock producer has sufficient available land base close to site this first strategy can be modified to fit a variety of options. Part or all of the secondary manure could be used to create as uniform a product as possible, or the producer could use this strategy over years to rotate manure application over a number of fields to ensure that crop removal of P205 meets the manure applied P205.

The second strategy analyzed was the method in which the primary cell and the secondary cell are pumped out as two separate storages. The primary cell was agitated and totally pumped out without using any secondary liquid manure. The goal was to create 2 separate products – concentrated primary cell manure and dilute liquid secondary manure. The primary only portion, which represented 31.1% of the total pump out, removed 97.8% of total P205. This pump out was done by a drag hose pumping company.

With creating 2 distinct products, both of which can still be pumped and applied with drag hose, the producer can begin to do specific target applications. The primary manure, containing most of the P205 can be pumped to fields with lower soil test P, and then the secondary manure applied to fields with higher soil test P at less than a 2x crop removal rate of P205.

The third strategy analyzed was the method in which some un-agitated liquid is bled off the top (approx. 18”-24”) of the primary cell and pumped into the secondary to give opportunity to even further concentrate the primary cell. This particular strategy occurred over a few days with 2 different pumping companies. The first event was pumping and applying unagitated secondary manure using a drag hose company. The second event was the aggressive agitation and removal of the now concentrated primary cell manure with tankers. This concentrated primary manure represented 28% of the total pump out, and removed 91.8% of total P205.

This strategy is especially applicable to a livestock producer whose available land base close to operation all has elevated soil test P. The secondary manure, which is very low in P205, can continue to be used on the close acres and spread at a 2x P205 crop removal, and the concentrated primary can be transported with tankers to fields further away. The economic implications of this third strategy was an increase of approx. 30% in cost (the cost for first two strategies was $0.01/imp gal and the third strategy overall cost was $0.0135/imp gal).

The 2-cell manure storage system can be a highly effective treatment solution using simple gravitational settling to its benefit. Pump out strategies or BMP’s (Best Management Practices) can be manipulated using common agitation tools and pumping or transport methods to meet agronomic P205 crop requirements and comply with current environmental regulations. Although these strategies may have increasing economic implications for affected livestock producers, they are much more economical than the present advanced treatment systems available. The results of this project, which was done at real life, large scale, and actual pump out events, provide assurance, support and data that support the strategies already implemented by some.

Table of Contents:

(A) Introduction

The majority of hog/livestock facilities were developed in Manitoba based on nitrogen land base requirements. Since the Manitoba Livestock Manure and Mortalities Regulation 42/98 was updated in 2006 (and is now in effect for the entire Province) to include phosphorus as well, a number of producers are required to consider the phosphorus accumulation in their soil and thus apply their livestock nutrients over a greater number of acres. Current regulations now limit how much manure P205 can be applied onto fields with soil test values of 60 ppm P or higher. Numerus operations have seen spread fields elevate in soil test P to levels above 60 ppm and thus find themselves significantly impacted by the limitations in manure application. Applying manure phosphorus further and further away from the livestock operation has increased the costs associated with pumping, application and transportation. In addition, since some operations are now facing high phosphorus on their nearby land base but would still like to have a nitrogen rich/phosphorus deficient nutrient product for this closer land while creating phosphorus rich (lower volume) product which can be more economically transported further away.

Creating a segregated phosphorus product using chemical, mechanical, or biological treatment is an expensive option for producers. If a livestock producer is in a position of limited land base due to high soil test P fields and if the 2 cell EMS treatment system (using gravity to separate) can achieve the phosphorus segregation desired, alternative treatment forms may be avoided or postponed for a number of years and therefore save the expense of an additional treatment system.

The 2 cell earthen manure storage (EMS) has historically provided a good solution for solids removal during manure application. These storages have been designed to contain the solids via gravitational settling in a smaller proportion (primary cell) of the manure storage to facilitate more efficient and effective agitation and solids removal during the pump out process. The primary cell is usually 25-30 % of the total volume of the storage. All the manure from the livestock facility gets pumped into the primary cell where it has time for gravitational settling of solids. Once the primary cell is full, the liquid portion of the manure begins to flow over into the secondary part of the storage via cross-over channel. The secondary part of the storage is usually 70-75% of the total volume of the storage. Some of these storages also have a back flow valve installed in the dividing berm to allow for secondary manure to be bled back into primary during pump out to liquefy solids if necessary. Manure analysis consistently shows that the majority of phosphorus is also concentrated in these solids in the primary cell of a 2 cell EMS. Different pump out strategies of these type of storages can be used as a tool to segregate phosphorus based on environmental and/or crop requirements. This project quantifies the nutrient profile throughout the pump out based on different pump out techniques.

Two different sites in Southeastern Manitoba were chosen for this project. This is also the area where some of the phosphorus challenges are and will be faced in the coming years. The sites are all multi-barn (2 barns each with total of 4000-6500 pig spaces) hog finishing sites and each with similar 2-cell manure storages. With all of the project sites being located in southeastern Manitoba, it also ensures very similar environmental impact from rain, snow or evaporation on these storages. Since both sites are part of one company, similar feed strategies are also being used. Three different pump out strategies were investigated in this project (a different one at each site). The specific strategy chosen for each site was determined based on the land base dynamics and specific field soil test values.

This project should result in the development of Beneficial Nutrient Management Practices for facilities with 2-cell earthen manure storage (EMS) systems. It will quantify dry matter and nutrient levels in two-cell EMS's and characterize how the solids and nutrient concentrations change throughout the pump-out based on three selected pump-out approaches. A livestock producer then, depending on the specific land base dynamics and soil test values, can choose which practice of agitating and pump out is most suited for that site.

(B) Materials and Methods

Two relatively similar finishing sites were chosen for this project. Both were two barn sites located in a relatively close geographic area, had two cell storages and were (are) on similar feeding management. Each of the three pump out events at the sites were to represent 11-12 months' worth of manure production. At both sites and at each of the three pump out events, manure was applied onto annual crop land.

It is worth noting that the results will demonstrate significant characteristics and trends based on each pump out strategy rather than precise representational data for each of the strategies. Although the sites and storages are similar, they may differ in feeder pig space, environmental impact from rain or snow, length of time from previous pump out, and different storage characteristics (like total size, percentage of primary versus secondary, depth of storage, and cross over channel depth). All of these dynamics may or may not have impact in exactly how much phosphorus is actually produced, captured in pump out and segregated into primary portion. These variations, however, should not have a bearing on developing and implementing best management practices.

At each of the sites an estimate was made in terms of the total volume that would be pumped. Multiple samples were collected with a similar strategy at each pump out. It was determined that at minimum we needed at least 1 sample for every 5% of the pump out. As well, in order avoid a "moment in time" possibility of a skewed sample, 3 sub samples were taken within each 5% of the pump out, also at determined intervals, and then combined and mixed to form this 1 sample. Accurate records of time and gallon progression were taken. Field notes of things like pump shut down, agitation, field changes, and cell changes were also taken (see Appendix). Since the estimate of total gallons could not be 100% predictable, total number of samples submitted per site varied from 18-24. Samples were collected and stored in cool place till they could be submitted to the lab. Manure nutrient contents and corresponding volumes were characterized based on each of the three pump-out strategies.

Since this project is analyzing manure from real life and large scale operations, challenges and "lack of control" were bound to surface. During the first step of the process of the third method pump out, while the secondary cell was being emptied, samples were taken to submit to the lab. However, due to very strong and strange odors and clear visible peculiarities with the secondary manure consistency, some questions began to surface regarding this site. As well, someone from site management had prior to this pumping event opened the valve in the dividing berm allowing primary manure to flow into secondary cell (valve and pipe are located very low in berm). When the lab analysis came back on first set of samples from secondary manure pump out, it became clear that this site needed to be abandoned from being part of this project. With the goal of finding another site with similar barn and manure storage designs and capacities, similar feeding strategies and located in similar geographic area, the decision was made to use the first site (strategy 1) for this third method. Due to the postponement, it was now just over 12 months since the first event occurred at this site.

1) **Common historical method**

Site, storage and strategy description:

- Located in RM of Hanover, close to Niverville
- 2 barn site with total of approx. 6400 finishing pig spaces
- Agitation in primary cell was done using a Nuhn "boat" agitator for approx. 60% of time, during secondary pump, it was sitting on a ramp not agitating at all.
- By visual observation only, some excess solids in primary cell left in 2014 might have been removed in this 2015 pump out, was approx. 12 months manure production from previous 2014 pump out.
- Total pump out (3280000 imp gals), Primary with some secondary (1450000 imp gals), Secondary (1830000 imp gals)
- Manure from the primary/secondary mix reached highest level of 10% dry matter content.
- The cost of this pump out was $0.0101/imp gal
- Primary cell dimensions (188' x 186' – approx. 31% of total volume by size), Secondary cell dimensions (188' x 424' – approx. 69% of total volume by size)

Method description: The primary cell was agitated and pump out began. This particular storage was so full that the manure level had reached 12-16" above the over flow channel. So as the primary was pumped, manure ran back into primary from secondary over the top of the over flow channel. This of course stopped once the total level in storage dropped. The primary was 60-75 % emptied and then a limited amount of secondary liquid manure was back-flushing into the primary to re-suspend the solids in the primary cell to create a more homogenous product. Once the primary was then as empty as necessary, the pump was moved over into the secondary cell to finish the pump out. This pump out was done by a drag hose pumping company.

2) **Pumping concentrated manure from the primary**:

Site, storage and srategy description:

- Located in RM of St. Anne, close to St. Anne
- 2 barn site with total of approx. 4000 finishing pig spaces
- Agitation in primary cell was done using a Nuhn "boat" agitator for approx. 60% of time, same pump used to pump secondary with no agitation.
- By visual observations only, it appears similar amount of solids taken out in 2015 as in 2014, was approx. 11 months manure production from previous 2014 pump out.
- Total pump out (2440000 imp gals), Primary only (770000 imp gals), Secondary only (1670000 imp gals).
- The primary portion represented 97.8% of the total P205 removed, the secondary portion represented 2.2% of the total P205 removed.
- Primary manure contained 10-11% dry matter, this reaches the upper limit of what can be pumped with conventional drag hose equipment.
- The cost of this pump out was $0.0101/imp gal
- Primary cell dimensions (164' x 155' – approx. 30% of total volume by size), Secondary cell dimensions (164' x 367' – approx. 70% of total volume by size).

Method description: The primary cell was agitated and totally pumped out without using any secondary liquid manure. Secondary manure would only be used as necessary to ensure a pump-able product. The goal was to create 2 separate products – concentrated primary cell and dilute secondary manure. The intended goals were accomplished. Primary cell was emptied quite well and then the pump was moved over into the secondary cell to finish the pump out. This pump out was done by a drag hose pumping company.

3) **Further concentrating the manure in the primary cell**

Site, storage and strategy description:

- Same site and storage as method 1 (due to the issues encountered as described earlier)
- No agitation used during secondary pump out
- Agitation in primary done with a Houle agitator/pump, with an additional Nuhn boat agitator used for approx. 12 hours to assist in the agitation.
- During the first 880000 gals of secondary pump out, unagitated liquid from primary bled over across channel into secondary cell. A total of 2515000 gals (73% of total volume) was pumped from secondary cell. This represented 8.2% of the total P205 removed.
- The cost of this portion of pump out was $0.0099/imp gal.
- Total of 952000 gallons (27% of total volume) of concentrated primary manure was hauled with tankers. This represented 91.8% of the total P205 removed.
- Primary manure contained 12-15% dry matter. This reaches the upper limit of what can be pumped into tankers using conventional equipment.
- The cost of this portion of pump out was $0.023/imp gal.
- The overall cost on the total volume (3467511 gals) was $0.0135/imp gal

- By visual observation, it was noted that using this method the primary was emptied further than the previous year with drag hose. Pump out was for approx. 13 months of production.

Method description: At this site, the total pump out occurred over period of 2 days in October, 2017, with 2 different pumping companies. Without any agitation in the primary or secondary cell, a drag hose pumping company began to pump out the secondary cell. Since the storage was quite full with the secondary and primary equalized over the crossover, the top 18-20" of un-agitated liquid from the primary was allowed to run over into the secondary as the secondary was being lowered. The goal was to further concentrate the solids in the primary cell with this decanting. This secondary manure was applied onto annual crop land with higher soil test P residual close to site. A tanker company then began to agitate the primary very aggressively with their Houle agitator. Since there appeared to be so many solids in the primary, the decision was made to not decant any more liquid off of the top of the primary. The tankers then hauled this concentrated primary manure to some annual crop land with low soil test P a 3.5 miles away from the site. During the process of emptying the primary, a second agitator (Nuhn boat) was used to assist in the agitating.

(C) Results

During each of the three pump out strategy events, the following data was captured:

1. The actual pump out data and agitation strategies used.

2. Videos/pictures of the equipment used for agitation and cleanout.

3. Manure samples taken at every 5% increment of the pump out (approx. 20 samples per pump out).

4. Running total of volume pumped associated with each 5% increment. This volume is used in estimating transportation costs and the amount of P that is being transported in each volume increment.

5. Manure characteristics analyzed: dry matter percentage, total phosphorus, total nitrogen, potassium, ammonium, copper, zinc, calcium, magnesium and sodium.

Based on the data and characteristics captured, the project will recommend Beneficial Nutrient Management Practices for the pump-out of 2-celled manure storage structures for feeder operations. Operations with either sufficient land base to balance P application or those with insufficient land base to balance P.

Although this study focused on strategies on P removal from 2-cell manure storage systems, a number of micro nutrients were also included in the lab analysis. The results also give clear indication that numerous micro nutrients are also segregated in the solids portion of the manure in the primary cell.

- Zinc (Zn) and copper (Cu) concentrations can be 45 times higher in the primary cell.
- Iron (Fe) concentrations can be 25 times higher in the primary cell.

See the actual data, graphs and pictures in appendix.

(D) Discussion and Potential Application

It is to be noted that due to the fact that this research was done on actual on-farm, large scale and annual pump out events, the research events were impacted by the normal day to day dynamics of pump out activities.

- Break down of equipment causing delays
- Mechanical agitation variation (Nuhn Boat vs traditional Houle)
- Field conditions (applicator getting stuck)
- Agitation shut down or delays
- Back flow valve plugged at one site.
- Weekend interruption
- Differences in solids left in primary (from site to site or to previous year)

The results of this project are very encouraging. They demonstrate that simple gravitational settling in a traditional 2 cell storage system can be utilized at a large scale operation to manage phosphorus for agronomic, environmental and economic reasons. Depending on land base dynamics at each specific site, one or more of these pump out strategies can be used or modified and applied. Before a producer would engage in a high cost venture of mechanical or biological separation, these low cost strategies should be investigated to determine whether they have beneficial value. These strategies may also be implemented on a graduated level, as in applying them over years as phosphorus issues may impact the operation on a slow yet growing scale.

The potential management practices that would have a beneficial impact on both agronomic and economic concerns would vary depending on each livestock operation's status of land availability and soil test phosphorus. The goal of each is to comply with present regulatory standards as well as ensuring the operation is both agronomically and environmentally sustainable. The following are a number of scenarios that demonstrate whether the results of this study would be beneficial or practical.

Some assumptions made in these scenarios are these;

Manure applicators using drag hose system are able to pump manure up to 3 or even 4 miles, although there are often then price premiums to be paid for distances above 2 – 2.5 miles. Thus the price could vary from $0.009 - $0.011 per gallon for fields < than 2.5 miles up to $0.0125 - $0.015 per gallon for fields up to 4 miles away. These scenarios will be assuming to have a maximum pumping distance of 2.5 – 3 miles, understanding that it would still be more economical to use drag hose pumping as compared to tankers within these distances.

Manure transport and application with tankers 5-10 miles is significantly more expensive. Depending on road conditions and dynamics, livestock site and field access, a 4-5-mile haul is approximately $0.025 per gallon and a 10-mile haul is approximately $0.04 per gallon.

Manure application onto fields with P soil test values >60 ppm have regulatory limits in terms of P205 application. P205 application from manure is then limited to crop removal levels depending on soil test levels and whether one is doing a multi-year application or not. These scenarios will use the 2x crop removal of P205 as the limit for these fields that may have elevated soil test P.

-

1. **Livestock producer with sufficient land base within 2.5 – 3 miles.** If the livestock producer has sufficient land base within 2.5 – 3 miles and is not seeing soil test P elevating significantly, this producer may not need to modify his management strategies at all. In fact, this operator could keep using the traditional method of agitation and pump out, in which the secondary cell is mixed back into the primary throughout the total process to create a uniform product for the entire pump out. Thus, other than the normal variabilities experienced with agitation, this producer is using the livestock manure P205 across the whole land base in the normal year to year rotations. Manure application of P205 can be balanced with appropriate crop rotations and sound agronomic management. Monitoring of soil test P through annual soil sampling will assist in ensuring long term sustainability of these livestock operations. The economics of manure application should not be significantly impacted since all of the manure can be utilized within reasonable pumping distances close to site. The cost of the total pump out should not significantly exceed $0.009-$0.011 per gallon up to distance of 3 miles.

2. **Livestock producer with sufficient land base within 2.5 – 3 miles but with some closer fields elevated in soil test P (>60 ppm).** If the livestock producer has sufficient land base within 2.5 – 3 miles but has begun to see elevated soil test P levels (>60 ppm) in some of the closer fields, it might be good management to begin to implement some of these strategies. It might well be that due to cost and convenience factors, the closer fields have received the majority of the manure over the years and thus the manure application of P205 has been greater than the cumulative crop removal of P205. With a 2-cell manure storage system, this producer can now begin to use the natural gravitational settling of solids in the primary cell to its advantage by beginning to segregate product during the pump out. Pump out and agitation strategies 1 and 2 could both work in this scenario. This producer, depending on crop rotation, needs to begin to do targeted application of manure P205. During the first 30-35% of the pump out, either using just a bit of secondary manure or none at all, the primary cell can be applied on to fields a bit further away that have lower soil test P. The remaining 65-70% of the pump out, which would be the secondary cell only, can be applied onto the closer fields that have elevated soil test P. These strategies become a significant improvement in agronomics with the manure P205 being applied onto fields and crops that can benefit from it. Drag hose manure applicators required to pump the higher solids content manure at a greater distance may be reluctant to do so due to a slower pump with higher hose pressures, however, with the increase usage of booster pumps with remote control and sensor technology, these issues become less and less of a concern. The cost of the total pump out should not significantly exceed $0.009-$0.011 per gallon up to distance of 3 miles.

3. **Livestock producer with insufficient land base within 2.5 – 3 miles due to elevated soil test P (>60 ppm) in numerous annual crop or hay fields.** If the livestock producer has seen soil test P elevate in most of the available spread fields (>60 ppm), pump out and application strategies will need to be implemented to keep this operation in a sustainable status. Management of manure needs to include moving manure P205 to fields further away. If those fields cannot be reached with a drag hose pump out, part of the primary cell could be transported via tankers to fields further away. Depending on cropping rotation, part of the P205 in primary could be mixed

with the secondary liquid to create a product that could still be applied on the close fields at a 2x or multi-year application rate.

A possible strategy could be the following. First decant some of the liquid off of the top of the primary cell. After 18-24" has been pumped over into the secondary (without agitation), begin aggressive agitation and tanker a portion of the now concentrated product to fields at greater distance (either annual crop, hay or pasture fields with low soil test P). Once 50% of this concentrated product has been removed with tankers, the producer can bring in a drag hose pumping company to pump out the remainder of the primary and secondary. Secondary liquid would now be used to significantly dilute the remaining primary manure and applied onto the closer fields at a 1x or 2x P205 removal rate.

Economic implications for using this strategy: Assuming the total pump out is 2.5 million gallons, and 15% of the total product (50% of concentrated primary) has been transported with tankers to fields 5 miles away, the average cost over the whole pump out would be $0.0131 per gallon (375000 gallons at $0.025 and 2125000 gallons at $0.011). Although there would be a moderate cost increase for this producer, it would be prudent to implement a strategy similar to this as soon as possible to keep closer fields from elevating in soil test P to levels that would eliminate them from future manure application.

4. **Livestock producer with insufficient land base within 2.5 – 3 miles due to elevated soil test P (>60 ppm) in all of available pasture fields.** This livestock producer faces significant issues in complying with present P205 manure application regulations. Not only are the available fields elevated to soil test P levels of 60-120 ppm, they are all in pasture management. Decisions will need to be made in terms of P management and what type of P205 segregation to use. Before costly options of mechanical or biological separation are considered, this producer should consider pump out strategy 3 used in this project.

   Since there is ample pasture land available, the secondary liquid portion of this product could still be applied at a 1x or 2x crop removal rate for pasture (assuming 7 lbs. P205) at 4500 – 7000 gallons per acre. All of the concentrated primary cell should be transported to low soil test P annual crop, hay or pasture fields further away. Here too, the top 18-24" of the liquid in the primary should be decanted and pumped over into the secondary. The primary should be then aggressively agitated and pumped out and transported via tankers.

   Economic implications for using this strategy: Assuming that the total pump out is 2.5 million gallons, and 25% of the total product (whole decanted primary) is transported with tankers to fields 10 miles away, the average cost of the whole pump out would be $0.01825 per gallon (625000 gallons at $0.04 and 1875000 gallons at $0.011). Although there is a significant cost increase for this producer, this management strategy is much more economical than the options of mechanical or biological separation. Here as well, the sooner this strategy is implemented at this operation, the higher potential of not having the close pasture fields elevate in soil test P to levels >120 ppm which might make them unavailable for even the secondary manure.

(E) Conclusions and Recommendations

The 2-cell manure storage system can be a highly effective treatment solution using simple gravitational settling to its benefit. Pump out strategies can be manipulated using common agitation tools and pumping or transport methods to meet agronomic P205 crop requirements and comply with current environmental regulations. In only extreme situations should Manitoba livestock producers require further advanced treatment beyond what can be achieved with a 2-cell manure storage system. Although these strategies may have increasing economic implications for affected livestock producers, they are much more economical than the present advanced treatment systems available. Based on a recent study done by Prairie Agricultural Machinery Institute for MLMMI to understand the economics of advanced phosphorus treatment and removal, "the overall cost of treatment in the case scenario was estimated to be a minimum of $0.035 / imp gal as compared to typical manure land application cost of $0.01 / imp gal." (Reference: MLMMI 2015-02 "Evaluation of Air Flotation and Belt Filter Press – Economics and Effectiveness" PAMI December 2015. http://www.manure.mb.ca/projects/viewproject.php?id=100)

For livestock operations that find themselves pressured with insufficient land base for manure application, the results of this study provide attainable, practical and economic options. In the higher concentrated livestock "special management zones" some of these strategies are already being implemented to differing degrees. Some producers have been proactive and seen that the P205 rich primary product from a 2 cell manure storage can be quite simply segregated and used on specific target fields or transported at greater distance. The results of this project, which was done at real life, large scale, and actual pump out events, provide assurance, support and data that support the strategies already attempted by some.

(F) Acknowledgements:

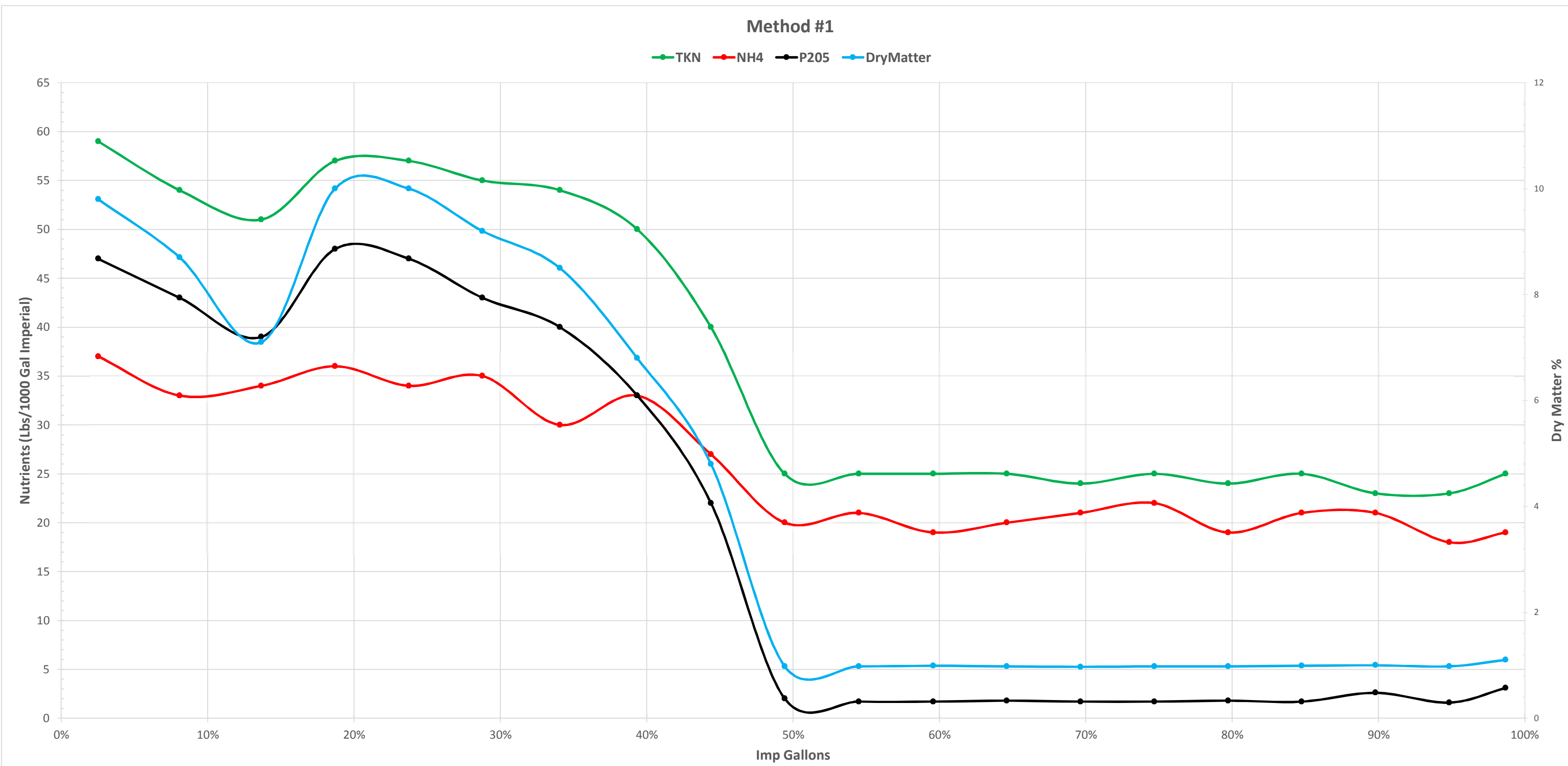
MLMMI, MLAF, Precision Pumping, Wiebe's Manuring, Agvise Labs

(G) Appendix:

Pictures, data and graphs

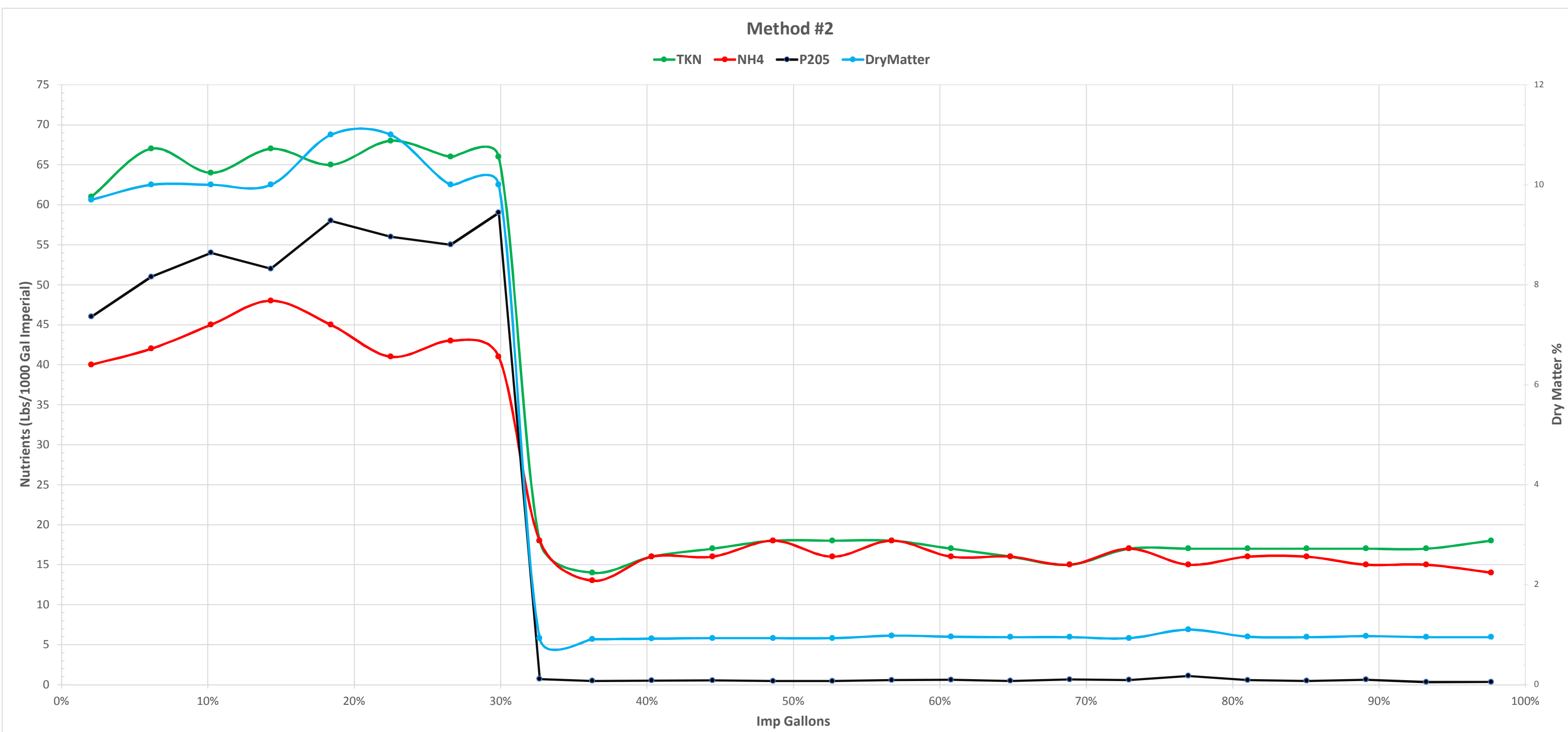
Method #1

								Percent %		lbs/1000 gal Imperial																
GrowerName	LabNumber	Mid Point	Percentage	Start	End	Total Gallons	SampleId	Moisture	DryMatter	TKN	NH4	P205	K2O	S	Ca	Mg	Na	Cu	Fe	Mn	Zn	Total #'s Phos	% of Phos	Cum Phos	Cum % of Storage	90% of Phos.
HERITAGE HOG	NW688	82500	3%	0	165000	165000	1	90	9.8	59	37	47	17	6.4	16	17	8.9	0.28	2.01	0.41	0.84	7755	12%	11.9%	5.0%	
HERITAGE HOG	NW689	265125	8%	165000	365249	200249	2	91	8.7	54	33	43	18	5.7	16	15	9.3	0.24	1.81	0.4	0.75	8611	13%	25.1%	11.1%	
HERITAGE HOG	NW690	447749	14%	365249	530249	165000	3	93	7.1	51	34	39	20	5	14	14	9.8	0.22	1.76	0.35	0.66	6435	10%	35.0%	16.2%	
HERITAGE HOG	NW691	612749	19%	530249	695249	165000	4	90	10	57	36	48	16	6.2	25	20	8	0.27	3.87	0.47	0.83	7920	12%	47.1%	21.2%	
HERITAGE HOG	NW692	777749	24%	695249	860249	165000	5	90	10	57	34	47	18	5.9	25	21	9	0.27	4.14	0.49	0.85	7755	12%	59.0%	26.3%	
HERITAGE HOG	NW693	942749	29%	860249	1025249	165000	6	91	9.2	55	35	43	19	5.9	19	18	9.5	0.26	2.95	0.42	0.73	7095	11%	69.9%	31.3%	
HERITAGE HOG	NW694	1115944	34%	1025249	1206639	181390	7	92	8.5	54	30	40	20	5.3	19	17	11	0.23	2.91	0.38	0.65	7256	11%	81.0%	36.8%	
HERITAGE HOG	NW695	1289139	39%	1206639	1371639	165000	8	93	6.8	50	33	33	18	4.4	15	14	9	0.22	2.33	0.32	0.58	5445	8%	89.4%	41.9%	40.7%
HERITAGE HOG	NW696	1454139	44%	1371639	1536639	165000	9	95	4.8	40	27	22	20	3	12	9.4	9.8	0.14	1.87	0.22	0.37	3630	6%	94.9%	46.9%	
HERITAGE HOG	NW697	1619139	49%	1536639	1701639	165000	10	99	0.98	25	20	2	23	0.68	1.2	0.18	11	0.02	0.074	0.012	0.04	330	1%	95.5%	51.9%	
HERITAGE HOG	NW698	1785357	54%	1701639	1869074	167435	11	99	0.98	25	21	1.7	22	0.63	0.94	0.11	10	0.017	0.068	0.0095	0.033	285	0%	95.9%	57.1%	
HERITAGE HOG	NW699	1951574	60%	1869074	2034074	165000	12	99	0.99	25	19	1.7	24	0.69	0.97	0.11	11	0.018	0.064	0.0093	0.036	281	0%	96.3%	62.1%	
HERITAGE HOG	NW700	2116574	65%	2034074	2199074	165000	13	99	0.98	25	20	1.8	22	0.66	1.1	0.12	11	0.02	0.068	0.011	0.038	297	0%	96.8%	67.1%	
HERITAGE HOG	NW701	2281574	70%	2199074	2364074	165000	14	99	0.97	24	21	1.7	21	0.64	1	0.11	11	0.018	0.065	0.0091	0.038	281	0%	97.2%	72.2%	
HERITAGE HOG	NW702	2446574	75%	2364074	2529074	165000	15	99	0.98	25	22	1.7	20	0.6	0.97	0.13	9.7	0.018	0.063	0.009	0.036	281	0%	97.6%	77.2%	
HERITAGE HOG	NW703	2611574	80%	2529074	2694074	165000	16	99	0.98	24	19	1.8	23	0.7	1	0.1	11	0.018	0.066	0.0098	0.038	297	0%	98.1%	82.2%	
HERITAGE HOG	NW704	2776574	85%	2694074	2859074	165000	17	99	0.99	25	21	1.7	21	0.61	0.96	0.12	10	0.018	0.063	0.0098	0.035	281	0%	98.5%	87.3%	
HERITAGE HOG	NW705	2941574	90%	2859074	3024074	165000	18	99	1	23	21	2.6	20	0.64	1.3	0.44	10	0.021	0.085	0.016	0.041	429	1%	99.2%	92.3%	
HERITAGE HOG	NW706	3106574	95%	3024074	3189074	165000	19	99	0.98	23	18	1.6	22	0.62	0.93	0.1	11	0.018	0.062	0.0089	0.035	264	0%	99.6%	97.3%	
HERITAGE HOG	NW707	3232494	99%	3189074	3275913	86839	20	99	1.1	25	19	3.1	21	0.67	1.5	0.59	10	0.024	0.1	0.02	0.045	269	0%	100.0%	100.0%	
						3275913																65194	100%			
							Mean	95.70	4.29	37.30	26.00	19.17	20.25	2.75	8.64	7.38	10.00	0.12	1.22	0.18	0.33					
							Count	20	20	20	20	20	20	20	20	20	20	20	20	20	20					
							Max	99.00	10.00	59.00	37.00	48.00	24.00	6.40	25.00	21.00	11.00	0.28	4.14	0.49	0.85					
							Min	90.00	0.97	23.00	18.00	1.60	16.00	0.60	0.93	0.10	8.00	0.02	0.06	0.01	0.03					
							Median	99.00	1.05	25.00	21.50	2.85	20.00	0.70	1.40	0.52	10.00	0.02	0.09	0.02	0.04					



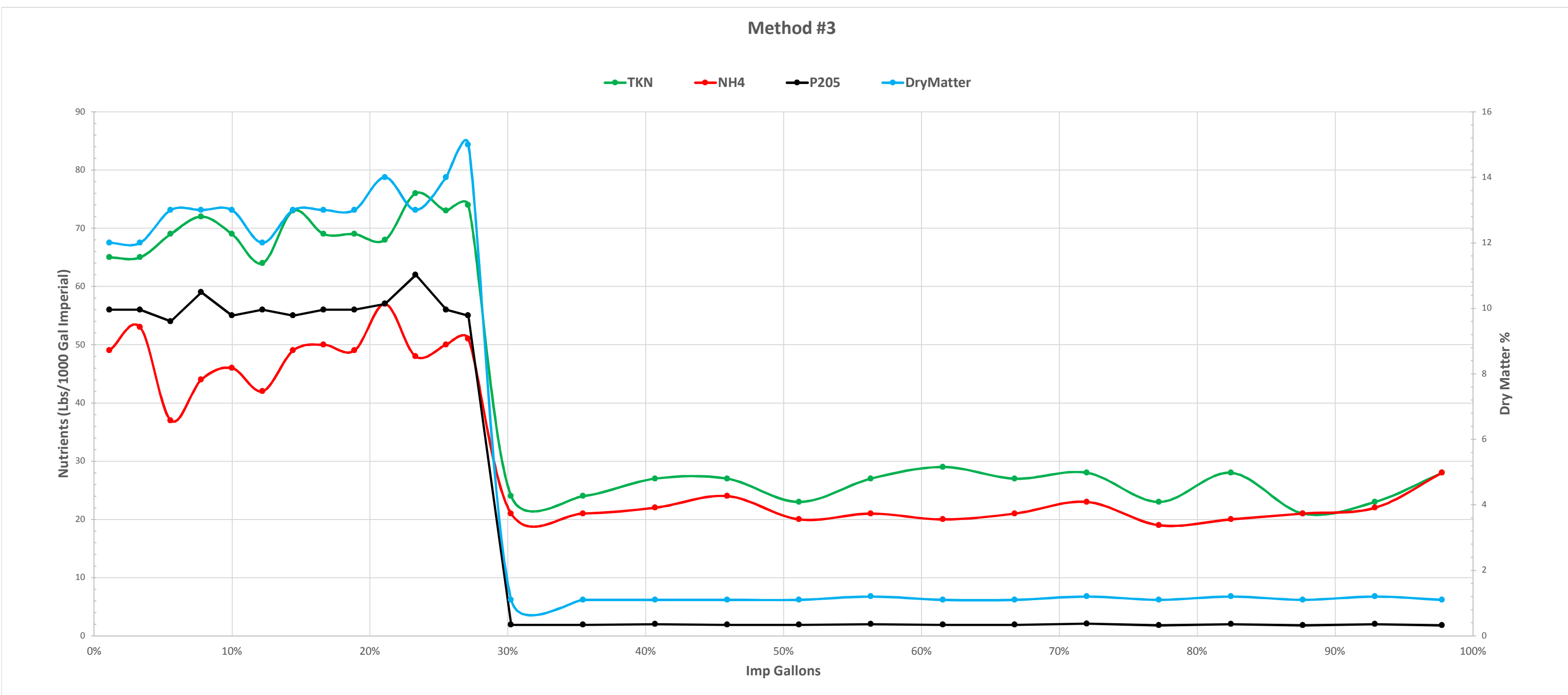
Method #2

								Percent %		lbs/1000 gal Imperial																
GrowerName	LabNumber	Mid Point	Percentage	Start	End	Total Gallons	SampleId	Moisture	DryMatter	TKN	NH4	P205	K2O	S	Ca	Mg	Na	Cu	Fe	Mn	Zn	Total #'s Phos	% of Phos	Cum Phos	Cum % of Storage	90% of Phos.
KBR	NW663	50000	2%	0	100000	100000	1	90	9.7	61	40	46	20	6.5	24	18	6.9	0.32	2.56	0.42	0.8	4600	11.0%	11.0%	4.1%	
KBR	NW664	150000	6%	100000	200000	100000	2	90	10	67	42	51	20	6.7	20	20	7.1	0.33	2.37	0.45	0.85	5100	12.2%	23.3%	8.2%	
KBR	NW665	250000	10%	200000	300000	100000	3	90	10	64	45	54	19	6.8	23	21	6.4	0.34	2.83	0.48	0.93	5400	13.0%	36.2%	12.3%	
KBR	NW666	350000	14%	300000	400000	100000	4	90	10	67	48	52	18	6.7	21	20	6.3	0.33	2.64	0.47	0.91	5200	12.5%	48.7%	16.4%	
KBR	NW667	450000	18%	400000	500000	100000	5	89	11	65	45	58	20	7.5	24	23	7	0.36	2.81	0.49	0.96	5800	13.9%	62.6%	20.5%	
KBR	NW668	550000	22%	500000	600000	100000	6	89	11	68	41	56	20	7.3	22	22	7.1	0.35	2.51	0.48	0.95	5600	13.4%	76.1%	24.5%	
KBR	NW669	650000	27%	600000	700000	100000	7	90	10	66	43	55	16	6.8	20	22	6	0.34	2.24	0.47	0.9	5500	13.2%	89.3%	28.6%	29.0%
KBR	NW670	730036	30%	700000	760071	60071	8	90	10	66	41	59	22	7.2	24	23	6.8	0.35	2.76	0.52	0.97	3544	8.5%	97.8%	31.1%	
KBR	NW671	798571	33%	760071	837071	77000	9	99	0.93	18	18	0.7	17	0.51	2.1	0.77	6	0.0085	0.068	0.0085	0.023	54	0.1%	97.9%	34.2%	
KBR	NW672	886571	36%	837071	936071	99000	10	99	0.91	14	13	0.48	16	0.46	1.8	0.67	5.8	0.0086	0.054	0.0064	0.018	48	0.1%	98.0%	38.3%	
KBR	NW673	985571	40%	936071	1035071	99000	11	99	0.92	16	16	0.52	17	0.51	2.1	0.73	6.2	0.0081	0.058	0.0067	0.021	51	0.1%	98.1%	42.3%	
KBR	NW674	1087114	44%	1035071	1139157	104086	12	99	0.93	17	16	0.53	16	0.48	2	0.69	6	0.0082	0.054	0.0066	0.02	55	0.1%	98.3%	46.6%	
KBR	NW675	1188657	49%	1139157	1238157	99000	13	99	0.93	18	18	0.45	18	0.46	1.9	0.7	6.1	0.0058	0.052	0.006	0.017	45	0.1%	98.4%	50.6%	
KBR	NW676	1287657	53%	1238157	1337157	99000	14	99	0.93	18	16	0.45	16	0.44	1.9	0.67	5.8	0.0066	0.049	0.0059	0.017	45	0.1%	98.5%	54.7%	
KBR	NW677	1386657	57%	1337157	1436157	99000	15	99	0.98	18	18	0.56	18	0.47	2.1	0.77	6.5	0.0076	0.11	0.0094	0.02	55	0.1%	98.6%	58.7%	
KBR	NW678	1485657	61%	1436157	1535157	99000	16	99	0.96	17	16	0.61	18	0.47	2.1	0.81	6.3	0.0075	0.093	0.0091	0.02	60	0.1%	98.8%	62.8%	
KBR	NW679	1584657	65%	1535157	1634157	99000	17	99	0.95	16	16	0.47	18	0.45	1.9	0.73	6.3	0.0071	0.057	0.0067	0.017	47	0.1%	98.9%	66.8%	
KBR	NW680	1683657	69%	1634157	1733157	99000	18	99	0.95	15	15	0.65	16	0.49	2	0.74	5.8	0.0077	0.074	0.0082	0.021	64	0.2%	99.0%	70.9%	
KBR	NW681	1782657	73%	1733157	1832157	99000	19	99	0.93	17	17	0.59	18	0.5	2.1	0.77	6.3	0.007	0.059	0.0073	0.022	58	0.1%	99.2%	74.9%	
KBR	NW682	1881657	77%	1832157	1931157	99000	20	99	1.1	17	15	1.1	18	0.56	3.1	1.2	6.6	0.012	0.47	0.022	0.032	109	0.3%	99.4%	79.0%	
KBR	NW683	1980657	81%	1931157	2030157	99000	21	99	0.96	17	16	0.57	18	0.46	2.1	0.8	6.3	0.007	0.12	0.0089	0.021	56	0.1%	99.6%	83.0%	
KBR	NW684	2079657	85%	2030157	2129157	99000	22	99	0.95	17	16	0.48	18	0.47	2	0.8	7	0.0077	0.071	0.007	0.019	48	0.1%	99.7%	87.1%	
KBR	NW685	2178657	89%	2129157	2228157	99000	23	99	0.97	17	15	0.63	18	0.47	2.1	0.79	6.3	0.008	0.11	0.0088	0.024	62	0.1%	99.8%	91.1%	
KBR	NW686	2279157	93%	2228157	2330157	102000	24	99	0.95	17	15	0.31	12	0.32	1.3	0.5	4.4	0.0048	0.044	0.0045	0.014	32	0.1%	99.9%	95.3%	
KBR	NW687	2387387	98%	2330157	2444616	114459	25	99	0.95	18	14	0.33	12	0.29	1.3	0.51	4.2	0.0042	0.054	0.005	0.013	38	0.1%	100.0%	100.0%	
						2444616																41671	100%			
							Mean	96.04	3.92	32.44	24.60	17.62	17.56	2.53	8.48	7.27	6.22	0.11	0.89	0.16	0.30					
							Count	25	25	25	25	25	25	25	25	25	25	25	25	25	25					
							Max	99.00	11.00	68.00	48.00	59.00	22.00	7.50	24.00	23.00	7.10	0.36	2.83	0.52	0.97					
							Min	89.00	0.91	14.00	13.00	0.31	12.00	0.29	1.30	0.50	4.20	0.00	0.04	0.00	0.01					
							Median	99.00	0.96	18.00	16.00	0.61	18.00	0.49	2.10	0.79	6.30	0.01	0.09	0.01	0.02					



Method #3

								Percent %		lbs/1000 gal Imperial																
GrowerName	LabNumber	Mid Point	Percentage	Start	End	Total Gallons	SampleId	Moisture	DryMatter	TKN	NH4	P205	K2O	S	Ca	Mg	Na	Cu	Fe	Mn	Zn	Total #'s Phos	% of Phos	Cum Phos	Cum % of Storage	90% of Phos.
HERITAGE HOGS	NW943	38250	1%	0	76500	76500	1	88	12	65	49	56	23	7.8	20	22	10	85	229	51	99	4284	7.3%	7.3%	2%	
HERITAGE HOGS	NW944	114750	3%	76500	153000	76500	2	88	12	65	53	56	21	8	24	21	9.2	85	217	49	108	4284	7.3%	14.6%	4%	
HERITAGE HOGS	NW945	191250	6%	153000	229500	76500	3	87	13	69	37	54	20	8	21	20	9.1	79	201	49	93	4131	7.1%	21.7%	7%	
HERITAGE HOGS	NW946	267750	8%	229500	306000	76500	4	87	13	72	44	59	22	9	19	22	11	85	217	48	105	4514	7.7%	29.4%	9%	
HERITAGE HOGS	NW947	344250	10%	306000	382500	76500	5	87	13	69	46	55	20	8	22	21	8.6	85	224	50	103	4208	7.2%	36.6%	11%	
HERITAGE HOGS	NW948	420750	12%	382500	459000	76500	6	88	12	64	42	56	20	8.4	21	21	9.1	85	213	49	98	4284	7.3%	43.9%	13%	
HERITAGE HOGS	NW949	497250	14%	459000	535500	76500	7	87	13	73	49	55	18	7.9	21	21	8.3	83	231	51	96	4208	7.2%	51.1%	16%	
HERITAGE HOGS	NW950	573750	17%	535500	612000	76500	8	87	13	69	50	56	19	8.3	30	21	8.6	84	280	54	108	4284	7.3%	58.4%	18%	
HERITAGE HOGS	NW951	650250	19%	612000	688500	76500	9	87	13	69	49	56	21	8.3	20	22	9.9	84	232	50	100	4284	7.3%	65.7%	20%	
HERITAGE HOGS	NW952	726750	21%	688500	765000	76500	10	86	14	68	57	57	18	8.4	25	22	8.2	90	291	54	104	4361	7.4%	73.2%	22%	
HERITAGE HOGS	NW953	803250	23%	765000	841500	76500	11	87	13	76	48	62	21	8.8	25	24	9.3	96	286	58	112	4743	8.1%	81.3%	24%	
HERITAGE HOGS	NW954	879750	26%	841500	918000	76500	12	86	14	73	50	56	19	8.4	26	23	8.3	90	331	54	107	4284	7.3%	88.6%	27%	27.5%
HERITAGE HOGS	NW955	935000	27%	918000	952000	34000	13	85	15	74	51	55	19	8.2	26	23	8.4	80	364	52	105	1870	3.2%	91.8%	28%	
HERITAGE HOGS	NW929	1042000	30%	952000	1132000	180000	14	99	1.1	24	21	1.9	22	0.69	0.98	0.12	10	2.9	6.8	0.87	4	342	0.6%	92.4%	33%	
HERITAGE HOGS	NW930	1222000	35%	1132000	1312000	180000	15	99	1.1	24	21	1.9	23	0.74	1	0.13	10	3.1	6.9	0.87	4.2	342	0.6%	93.0%	38%	
HERITAGE HOGS	NW931	1402000	41%	1312000	1492000	180000	16	99	1.1	27	22	2	24	0.78	1	0.13	11	3.2	9	0.94	4.2	360	0.6%	93.6%	43%	
HERITAGE HOGS	NW932	1582000	46%	1492000	1672000	180000	17	99	1.1	27	24	1.9	22	0.78	1	0.13	10	3.5	6.9	0.88	4.4	342	0.6%	94.2%	49%	
HERITAGE HOGS	NW933	1761433	51%	1672000	1850865	178865	18	99	1.1	23	20	1.9	22	0.76	1	0.13	10	3.3	6.7	0.92	4.3	340	0.6%	94.8%	54%	
HERITAGE HOGS	NW934	1940865	56%	1850865	2030865	180000	19	99	1.2	27	21	2	22	0.76	1	0.15	9.8	3.2	6.9	0.99	4.4	360	0.6%	95.4%	59%	
HERITAGE HOGS	NW935	2120865	62%	2030865	2210865	180000	20	99	1.1	29	20	1.9	22	0.76	1	0.12	10	3.2	6.5	0.91	4.1	342	0.6%	96.0%	64%	
HERITAGE HOGS	NW936	2300865	67%	2210865	2390865	180000	21	99	1.1	27	21	1.9	23	0.8	1	0.13	11	3.3	6.7	0.91	4.1	342	0.6%	96.5%	69%	
HERITAGE HOGS	NW937	2480865	72%	2390865	2570865	180000	22	99	1.2	28	23	2.1	24	0.78	1.1	0.19	11	3.3	7.8	1.1	3.9	378	0.6%	97.2%	75%	
HERITAGE HOGS	NW938	2660865	77%	2570865	2750865	180000	23	99	1.1	23	19	1.8	22	0.71	0.97	0.13	10	3	6.1	0.86	3.8	324	0.6%	97.7%	80%	
HERITAGE HOGS	NW939	2840865	82%	2750865	2930865	180000	24	99	1.2	28	20	2	23	0.76	1	0.14	10	3.3	7	0.92	4	360	0.6%	98.4%	85%	
HERITAGE HOGS	NW940	3020865	88%	2930865	3110865	180000	25	99	1.1	21	21	1.8	24	0.73	1	0.13	11	3.2	6.2	0.88	3.8	324	0.6%	98.9%	90%	
HERITAGE HOGS	NW941	3200865	93%	3110865	3290865	180000	26	99	1.2	23	22	2	23	0.8	1.1	0.14	11	3.6	8.3	1	4.4	360	0.6%	99.5%	96%	
HERITAGE HOGS	NW942	3368184	98%	3290865	3445503	154638	27	99	1.1	28	28	1.8	21	0.74	0.95	0.13	9.8	3.2	8	0.9	3.9	278	0.5%	100.0%	100%	
						3445503																58531	100%			
							Mean	93.19	6.88	46.85	34.37	28.14	21.41	4.37	11.63	10.55	9.73	42.83	126.51	25.26	51.69					
							Count	27	27	27	27	27	27	27	27	27	27	27	27	27	27					
							Max	99.00	15.00	76.00	57.00	62.00	24.00	9.00	30.00	24.00	11.00	96.00	364.00	58.00	112.00					
							Min	85.00	1.10	21.00	19.00	1.80	18.00	0.69	0.95	0.12	8.20	2.90	6.10	0.86	3.80					
							Median	99.00	1.20	29.00	28.00	2.10	22.00	0.80	1.10	0.19	10.00	3.60	9.00	1.10	4.40					



GrowerName	LabNumber			SampleId	Moisture	DryMatter	N_per_AsRec	NH4_N_per_AsRec	P_per_AsRec	K_per_AsRec	S_per_AsRec	Ca_per_AsRec	Mg_per_AsRec	Na_per_AsRec	Cu_per_AsRec	Fe_per_AsRec	Mn_per_AsRec	Zn_per_AsRec
KBR	NW663			1	90	9.7	0.61	0.4	0.46	0.2	0.065	0.24	0.18	0.069	32	256	42	80
KBR	NW664			2	90	10	0.67	0.42	0.51	0.2	0.067	0.2	0.2	0.071	33	237	45	85
KBR	NW665			3	90	10	0.64	0.45	0.54	0.19	0.068	0.23	0.21	0.064	34	283	48	93
KBR	NW666			4	90	10	0.67	0.48	0.52	0.18	0.067	0.21	0.2	0.063	33	264	47	91
KBR	NW667			5	89	11	0.65	0.45	0.58	0.2	0.075	0.24	0.23	0.07	36	281	49	96
KBR	NW668			6	89	11	0.68	0.41	0.56	0.2	0.073	0.22	0.22	0.071	35	251	48	95
KBR	NW669			7	90	10	0.66	0.43	0.55	0.16	0.068	0.2	0.22	0.06	34	224	47	90
KBR	NW670			8	90	10	0.66	0.41	0.59	0.22	0.072	0.24	0.23	0.068	35	276	52	97
KBR	NW671			9	99	0.93	0.18	0.18	0.007	0.17	0.0051	0.021	0.0077	0.06	0.85	6.8	0.85	2.3
KBR	NW672			10	99	0.91	0.14	0.13	0.0048	0.16	0.0046	0.018	0.0067	0.058	0.86	5.4	0.64	1.8
KBR	NW673			11	99	0.92	0.16	0.16	0.0052	0.17	0.0051	0.021	0.0073	0.062	0.81	5.8	0.67	2.1
KBR	NW674			12	99	0.93	0.17	0.16	0.0053	0.16	0.0048	0.02	0.0069	0.06	0.82	5.4	0.66	2
KBR	NW675			13	99	0.93	0.18	0.18	0.0045	0.18	0.0046	0.019	0.007	0.061	0.58	5.2	0.6	1.7
KBR	NW676			14	99	0.93	0.18	0.16	0.0045	0.16	0.0044	0.019	0.0067	0.058	0.66	4.9	0.59	1.7
KBR	NW677			15	99	0.98	0.18	0.18	0.0056	0.18	0.0047	0.021	0.0077	0.065	0.76	11	0.94	2
KBR	NW678			16	99	0.96	0.17	0.16	0.0061	0.18	0.0047	0.021	0.0081	0.063	0.75	9.3	0.91	2
KBR	NW679			17	99	0.95	0.16	0.16	0.0047	0.18	0.0045	0.019	0.0073	0.063	0.71	5.7	0.67	1.7
KBR	NW680			18	99	0.95	0.15	0.15	0.0065	0.16	0.0049	0.02	0.0074	0.058	0.77	7.4	0.82	2.1
KBR	NW681			19	99	0.93	0.17	0.17	0.0059	0.18	0.005	0.021	0.0077	0.063	0.7	5.9	0.73	2.2
KBR	NW682			20	99	1.1	0.17	0.15	0.011	0.18	0.0056	0.031	0.012	0.066	1.2	47	2.2	3.2
KBR	NW683			21	99	0.96	0.17	0.16	0.0057	0.18	0.0046	0.021	0.008	0.063	0.7	12	0.89	2.1
KBR	NW684			22	99	0.95	0.17	0.16	0.0048	0.18	0.0047	0.02	0.008	0.07	0.77	7.1	0.7	1.9
KBR	NW685			23	99	0.97	0.17	0.15	0.0063	0.18	0.0047	0.021	0.0079	0.063	0.8	11	0.88	2.4
KBR	NW686			24	99	0.95	0.17	0.15	0.0031	0.12	0.0032	0.013	0.005	0.044	0.48	4.4	0.45	1.4
KBR	NW687			25	99	0.95	0.18	0.14	0.0033	0.12	0.0029	0.013	0.0051	0.042	0.42	5.4	0.5	1.3
HERITAGE HOG	NW688			1	90	9.8	0.59	0.37	0.47	0.17	0.064	0.16	0.17	0.089	28	201	41	84
HERITAGE HOG	NW689			2	91	8.7	0.54	0.33	0.43	0.18	0.057	0.16	0.15	0.093	24	181	40	75
HERITAGE HOG	NW690			3	93	7.1	0.51	0.34	0.39	0.2	0.05	0.14	0.14	0.098	22	176	35	66
HERITAGE HOG	NW691			4	90	10	0.57	0.36	0.48	0.16	0.062	0.25	0.2	0.08	27	387	47	83
HERITAGE HOG	NW692			5	90	10	0.57	0.34	0.47	0.18	0.059	0.25	0.21	0.09	27	414	49	85
HERITAGE HOG	NW693			6	91	9.2	0.55	0.35	0.43	0.19	0.059	0.19	0.18	0.095	26	295	42	73
HERITAGE HOG	NW694			7	92	8.5	0.54	0.3	0.4	0.2	0.053	0.19	0.17	0.11	23	291	38	65
HERITAGE HOG	NW695			8	93	6.8	0.5	0.33	0.33	0.18	0.044	0.15	0.14	0.09	22	233	32	58
HERITAGE HOG	NW696			9	95	4.8	0.4	0.27	0.22	0.2	0.03	0.12	0.094	0.098	14	187	22	37
HERITAGE HOG	NW697			10	99	0.98	0.25	0.2	0.02	0.23	0.0068	0.012	0.0018	0.11	2	7.4	1.2	4
HERITAGE HOG	NW698			11	99	0.98	0.25	0.21	0.017	0.22	0.0063	0.0094	0.0011	0.1	1.7	6.8	0.95	3.3
HERITAGE HOG	NW699			12	99	0.99	0.25	0.19	0.017	0.24	0.0069	0.0097	0.0011	0.11	1.8	6.4	0.93	3.6
HERITAGE HOG	NW700			13	99	0.98	0.25	0.2	0.018	0.22	0.0066	0.011	0.0012	0.11	2	6.8	1.1	3.8
HERITAGE HOG	NW701			14	99	0.97	0.24	0.21	0.017	0.21	0.0064	0.01	0.0011	0.11	1.8	6.5	0.91	3.8
HERITAGE HOG	NW702			15	99	0.98	0.25	0.22	0.017	0.2	0.006	0.0097	0.0013	0.097	1.8	6.3	0.9	3.6
HERITAGE HOG	NW703			16	99	0.98	0.24	0.19	0.018	0.23	0.007	0.01	0.001	0.11	1.8	6.6	0.98	3.8
HERITAGE HOG	NW704			17	99	0.99	0.25	0.21	0.017	0.21	0.0061	0.0096	0.0012	0.1	1.8	6.3	0.98	3.5
HERITAGE HOG	NW705			18	99	1	0.23	0.098	0.026	0.2	0.0064	0.013	0.0044	0.1	2.1	8.5	1.6	4.1
HERITAGE HOG	NW706			19	99	0.98	0.23	0.18	0.016	0.22	0.0062	0.0093	0.001	0.11	1.8	6.2	0.89	3.5
HERITAGE HOG	NW707			20	99	1.1	0.25	0.19	0.031	0.21	0.0067	0.015	0.0059	0.1	2.4	10	2	4.5
HERITAGE HOGS	NW943			1	88	12	0.65	0.49	0.56	0.23	0.078	0.2	0.22	0.1	85	229	51	99
HERITAGE HOGS	NW944			2	88	12	0.65	0.53	0.56	0.21	0.08	0.24	0.21	0.092	85	217	49	108
HERITAGE HOGS	NW945			3	87	13	0.69	0.37	0.54	0.2	0.08	0.21	0.2	0.091	79	201	49	93
HERITAGE HOGS	NW946			4	87	13	0.72	0.44	0.59	0.22	0.09	0.19	0.22	0.11	85	217	48	105
HERITAGE HOGS	NW947			5	87	13	0.69	0.46	0.55	0.2	0.08	0.22	0.21	0.086	85	224	50	103
HERITAGE HOGS	NW948			6	88	12	0.64	0.42	0.56	0.2	0.084	0.21	0.21	0.091	85	213	49	98
HERITAGE HOGS	NW949			7	87	13	0.73	0.49	0.55	0.18	0.079	0.21	0.21	0.083	83	231	51	96
HERITAGE HOGS	NW950			8	87	13	0.69	0.5	0.56	0.19	0.083	0.3	0.21	0.086	84	280	54	108
HERITAGE HOGS	NW951			9	87	13	0.69	0.49	0.56	0.21	0.083	0.2	0.22	0.099	84	232	50	100
HERITAGE HOGS	NW952			10	86	14	0.68	0.57	0.57	0.18	0.084	0.25	0.22	0.082	90	291	54	104
HERITAGE HOGS	NW953			11	87	13	0.76	0.48	0.62	0.21	0.088	0.25	0.24	0.093	96	286	58	112
HERITAGE HOGS	NW954			12	86	14	0.73	0.5	0.56	0.19	0.084	0.26	0.23	0.083	90	331	54	107
HERITAGE HOGS	NW955			13	85	15	0.74	0.51	0.55	0.19	0.082	0.26	0.23	0.084	80	364	52	105
HERITAGE HOGS	NW929			14	99	1.1	0.24	0.21	0.019	0.22	0.0069	0.0098	0.0012	0.1	2.9	6.8	0.87	4
HERITAGE HOGS	NW930			15	99	1.1	0.24	0.21	0.019	0.23	0.0074	0.01	0.0013	0.1	3.1	6.9	0.87	4.2
HERITAGE HOGS	NW931			16	99	1.1	0.27	0.22	0.02	0.24	0.0078	0.01	0.0013	0.11	3.2	9	0.94	4.2
HERITAGE HOGS	NW932			17	99	1.1	0.27	0.24	0.019	0.22	0.0078	0.01	0.0013	0.1	3.5	6.9	0.88	4.4
HERITAGE HOGS	NW933			18	99	1.1	0.23	0.2	0.019	0.22	0.0076	0.01	0.0013	0.1	3.3	6.7	0.92	4.3
HERITAGE HOGS	NW934			19	99	1.2	0.27	0.21	0.02	0.22	0.0076	0.01	0.0015	0.098	3.2	6.9	0.99	4.4
HERITAGE HOGS	NW935			20	99	1.1	0.29	0.2	0.019	0.22	0.0076	0.01	0.0012	0.1	3.2	6.5	0.91	4.1
HERITAGE HOGS	NW936			21	99	1.1	0.27	0.21	0.019	0.23	0.008	0.01	0.0013	0.11	3.3	6.7	0.91	4.1
HERITAGE HOGS	NW937			22	99	1.2	0.28	0.23	0.021	0.24	0.0078	0.011	0.0019	0.11	3.3	7.8	1.1	3.9
HERITAGE HOGS	NW938			23	99	1.1	0.23	0.19	0.018	0.22	0.0071	0.0097	0.0013	0.1	3	6.1	0.86	3.8
HERITAGE HOGS	NW939			24	99	1.2	0.28	0.2	0.02	0.23	0.0076	0.01	0.0014	0.1	3.3	7	0.92	4
HERITAGE HOGS	NW940			25	99	1.1	0.21	0.21	0.018	0.24	0.0073	0.01	0.0013	0.11	3.2	6.2	0.88	3.8
HERITAGE HOGS	NW941			26	99	1.2	0.23	0.22	0.02	0.23	0.008	0.011	0.0014	0.11	3.6	8.3	1	4.4
HERITAGE HOGS	NW942			27	99	1.1	0.28	0.28	0.018	0.21	0.0074	0.0095	0.0013	0.098	3.2	8	0.9	3.9

Nuhn boat agitator/pump feeding drag hose applicator in primary cell at first strategy

Nuhn boat agitator/pump feeding drag hose applicator in secondary cell at first strategy

Cross over channel between primary and secondary cell at first and third strategy

Field drag hose application

Finished primary cell at second strategy

Nuhn boat agitator/pump in secondary at second strategy

Tractor with Houle agitator/loading pump in concentrated primary cell at third strategy

Nuhn boat agitator assisting in agitating concentrated primary cell at third strategy