

## The Lower Fox River and Green Bay TMDL Project

### *Agriculture Management Practices Costs and Implementation Rates*

Agriculture Management Practice	Maximum Implementation Rate (%)	Estimated Implementation Cost (\$/acre)(\$/A.U.)
1. Nutrient Management (reduce phosphorus in dairy cow feed ration by 25%)	90%	\$0
2. Manure Incorporation (increase proportion of applied manure that is incorporated within 72 hours)	85%	\$1,247.45 / AU (average of costs in Table 6)
3. Nutrient Management (stabilize soil-test phosphorus average at current average of 40 ppm (Bray P1)	90%	(\$125/AU) X (total AU) / (county) X ([0.2] X [non-forage acres])
4. Conservation Tillage (mulch tillage and zone tillage)	60% (mulch-till), 15% (zone-till), with total conservation tillage not to exceed 60%	\$15 (mulch-till) and \$20.50 (zone-till)/acre
5. Cover Crops (on low residue fields)	72%	\$61.63 / acre
6. Vegetative Buffer Strips	100%	\$3,500*
7. Decrease Soil Phosphorus Levels from 40 ppm to 25ppm [Bray P1]	35%	\$267.20/AU
8. Biofuel Crops	7%	\$363.51/acre
9. Water Sediment Control Basins	1%	\$386.58/acre (average of costs in Table 11)
10. Anionic Polyacrylamide	0%	Deemed infeasible for analysis; see summary for BMP #10

\* One time expense

## **BMP #1 - Nutrient Management (reduce phosphorus in dairy cow feed ration by 25%)**

Dietary phosphorus in dairy cow feed ration frequently exceeds the required amount. A 2008 study conducted in Wisconsin found that phosphorus, when fed to cattle in amounts greater than they can utilize, is excreted in the manure. If phosphorus-rich manure is later spread on farm fields to provide nutrients for growing crops, it may cause an excess of phosphorus in runoff that may end up in lakes where it can promote the undesirable growth of algae.

Phosphorus is essential for bone growth and development in growing dairy heifers. The amount of phosphorus that they need to consume is very similar to the amount that is typically found in their unsupplemented diets, suggesting that supplemental phosphorus in heifer diets may be minimally required. The Marshfield Agricultural Research Station conducted a study on heifers from 4 to 22 months of age. Heifers were fed diets with or without supplemental phosphorus resulting in manure phosphorus concentrations of 0.39 or 0.29 percent respectively. The researchers intensively evaluated bone growth, composition, and metabolism on a sub-group of these heifers. Results show that supplementing phosphorus to heifers had no effect on the extent of frame development, bone density, or bone metabolism. This information will help dairy producers and their nutritionists formulate heifer rations that contain adequate, but not excessive, amounts of phosphorus so that the growth needs of the heifers are met without adding excess phosphorus to the environment. (Hoffman 2008)

For lactating dairy cows, matching ration P content (%) to the amount of milk produced by different management groups within the herd or the whole herd is important. To do this effectively, knowledge of the rate of feed intake of the different management groups within the herd is necessary. As a reference, the National Research Council's (2001) feeding recommendations are used (examples are in Table 1). Note that the highest concentration of P recommended for high producing cows is only 0.38% on a dry basis.

**Table 1. Phosphorus feeding recommendations for lactating dairy cows\***

Milk yield (lb/cow/day)	Ration P (% , dry basis)
55	0.32
77	0.35
99	0.36
120	0.38

\* Assumes feed intake rates of the NRC (2001) model.

For this nutrient management scenario, phosphorus in dairy cow feed ration is reduced by 25% as compared to 2000 levels. The maximum implementation rate is set at 90%, which implies that 90% of the total manure produced and applied in the basin contains 25% less phosphorus due to an associated reduction in the dairy feed ration. This translates to roughly a 25% reduction in manure phosphorus concentrations. A detailed justification of these assumptions is described in Baumgart (2005). The fertilizer/manure SWAT input file was adjusted accordingly to simulate this scenario.

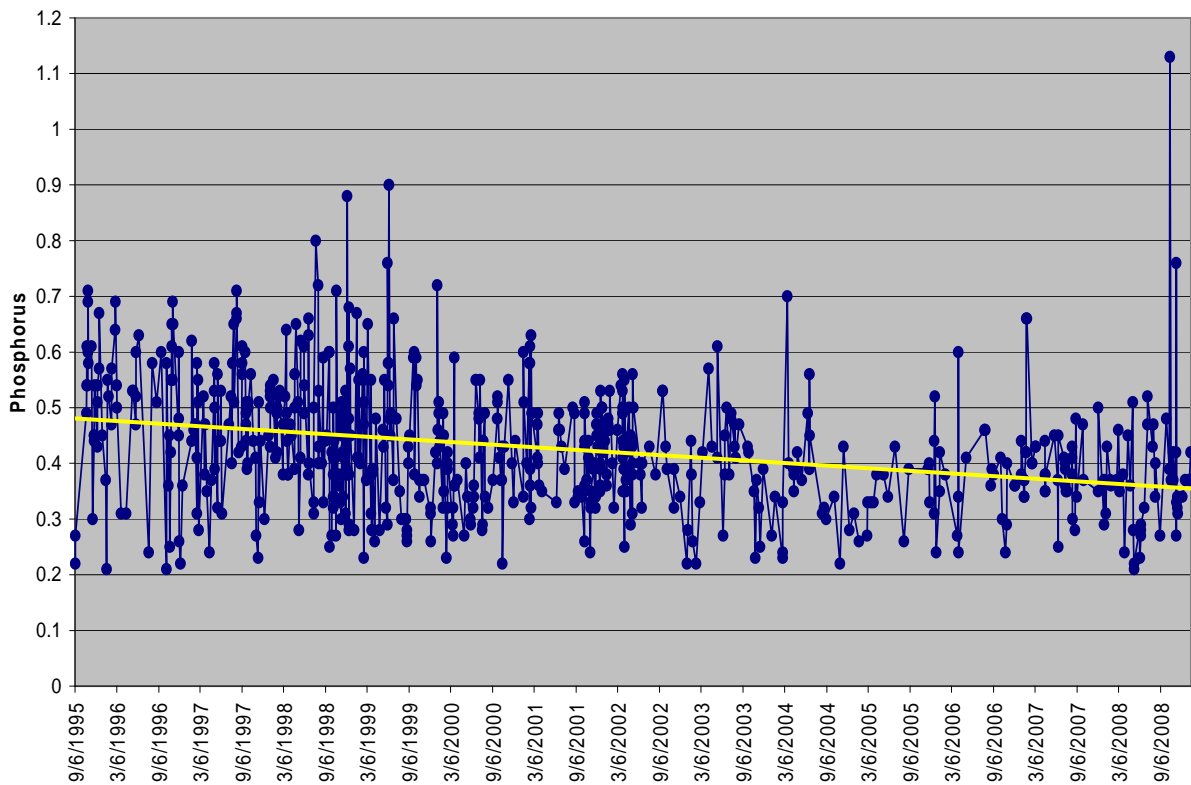
Feeding dairy cattle is more complex than other livestock because it requires balancing for requirements of animals at many stages of their lactation and pregnancy cycles, as well as balancing for the needs of the rumen's microbial population. Also, a dairy farm often utilizes hay and silage

grown on the farm with large variations in quality and nutrient content due to differences in soil, weather during harvest, and storage conditions.

Dietary phosphorus management can be implemented on farms of any size. Obstacles to adoption are education, the cost of forage analysis, and technical support to implement and monitor the best strategy for individual farms. Reductions in manure phosphorus content of 15 to 40 percent are feasible. On a majority of dairy farms, no supplemental phosphorus is needed to meet dietary requirements and eliminating overfeeding of P can reduce feed costs by \$10-\$15 per cow per year. The increased use of Nutrient Management Plans and the increasing expense of dietary phosphorus supplementation in recent years are the likely causes of the reduced phosphorus levels observed in rations (Figure 1). The cost of implementation is relatively low, but the degree of management intensity and sophistication required is high.

Farms implementing this strategy are already absorbing the additional management costs to ensure successful implementation. Therefore, no net costs (\$0) were assumed for this BMP scenario because the BMP is already being implemented and trend lines indicate that the practice is working. There will be a transition cost for the operations not testing their feed, but we expect the long term savings in manure application and reduced feed P purchases will offset this cost, given the current trends (Figure 1).

**Figure 1. Dairy Ration Phosphorus Trends in the Lower Fox River Basin (Source: TMR wet chemistry data provided by the Ag Source Soil and Forage Lab in Bonduel WI)**



**BMP #2 - Manure Incorporation (increase proportion of applied manure that is incorporated within 72 hours)**

Manure, like fertilizer, has a very high concentration of soluble phosphorus. If a rainfall event occurs soon after a surface application of manure, the concentration of soluble phosphorus in the runoff can be extremely high. Incorporating manure into soil (as opposed to just applying it to the field, on top of the soil) will minimize flash losses of soluble phosphorus associated with rainfall runoff events. In this scenario, the level of manure incorporated into soil immediately or within 72 hours following application is assumed to be 50% for 2004 baseline conditions, which is the same level utilized by Baumgart (2005). The remaining manure is applied as produced or as the short-term storage is emptied without intentional incorporation. The maximum implementation rate was set at 85%, which implies that manure incorporation is taking place on up to 85% of agricultural land in the basin where manure is applied.

In order to effectively manage timely spreading and incorporation of manure, storage needs to be available for facilities that are currently land spreading during the winter months. Table 2 details livestock and herd distribution for Brown, Calumet, Manitowoc, Outagamie, and Winnebago Counties. Table 3 reflects the spreadsheets developed from the herds that have been identified in the Lower Fox River Basin. Edited spreadsheets are in Appendix A. Table 4 summarizes cost estimates of constructing Manure storage for 165 and 350 Animal Unit facilities. It should be noted that these costs are highly volatile due to changes in concrete and fuel prices. This scenario is intended to be implemented at a maximum implementation rate of 85%, an average herd size of 138 cows plus replacements and a cost as depicted at the 175 head rate in Table 6 on the herd numbers detailed in Table 3. Animal Units Calculation worksheet and data on individual counties is provided in Appendix A.

**Table 2. Summary of livestock and herd distribution**

	Brown	Calumet	Manitowoc	Outagamie	Winnebago	Average
Cows	41,000*	27,000	45,000	37,000	15,900	
	39,020**	28,222	45,704	37,681	16,657	
# Herds	245	191	321	281	133	
	253	198	318	283	143	
Avg. Herd Size	167	141	140	132	120	140
	154	142	143	133	116	138
A.U. Conversion	78,776	51,646	83,612	71,948	30,387	
Total Cattle & Calves	105,000	58,000	97,000	83,000	33,000	
	104,312	60,705	97,330	86,472	33,372	

\* Top line source: 2008 Wisconsin Ag Statistics reflecting 2007 information

\*\* Bottom line source: 2009 USDA Ag Census reflecting 2007 information

**Table 3. Detail of facilities without manure storage**

	Brown	Calumet	Manitowoc	Outagamie	Winnebago
Herds in Watershed Area	139	45	3	104	2
Herds without long term manure storage	58	7	3	49	2

**Table 4. Cost of manure storage**

Manure Storage (1 year)	Cost Estimate 165 AU with Replacements	Cost Estimate 350 AU with Replacements
Earthen in-place*	\$35,000 - \$45,000	\$85,000 - \$90,000
Clay lined*	\$75,000 - \$80,000	\$130,000 - \$135,000
Concrete lined*	\$115,000 - \$120,000	\$195,000 - \$205,000
Slurry store**	\$225,000 - \$230,000	\$340,000 - \$350,000
Concrete walled structure (7 months)*	\$120,000 - \$125,000	\$170,000 - \$175,000

\*Brown County Land and Water Conservation (Chris Flicek)

\*\*Foxland Harvestore (Mike Gries)

**Table 5. Cost per AU**

Manure Storage (1 year)	Cost per AU - Estimate 165 AU with Replacements	Cost per AU - Estimate 350 AU with Replacements
Earthen in-place	\$242.42	\$250.00
Clay lined	\$469.70	\$378.57
Concrete lined	\$712.12	\$571.43
Slurry store	\$1,378.79	\$985.71
Concrete walled structure (7 months)	\$742.42	\$492.86

**Table 6. Cost per Cow and replacement**

Manure Storage (1 year)	Cost per Lactating Cow and Replacement - Estimate 82 cows and replacements	Cost per Lactating Cow and Replacement - Estimate 175 cows and replacements
Earthen in-place	\$487.81	\$500.00
Clay lined	\$945.12	\$757.14
Concrete lined	\$1,432.93	\$1,142.86
Slurry store	\$2,757.58	\$1,971.43
Concrete walled structure (7 months)	\$1,493.90	\$985.71

Per Wisconsin DNR Form 3400-25A

165 AU reflects 82 lactating cows and replacements

350 AU reflects 175 lactating cows and replacements

**BMP #3 - Nutrient Management (stabilize soil-test phosphorus averages at current average of 40 ppm [Bray P1])**

This nutrient management scenario simulates the estimated effect of an enhanced phosphorus-based nutrient management plan, which requires that phosphorus inputs be limited to crop needs, thereby stabilizing soil-test phosphorus levels such that they remain at the current average level of 40 ppm. Under 2007 cropping conditions, there was a net loss of Phosphorus when comparing P crop removal vs. P production from livestock in all counties examined (see Table 7). This means that each county has a sufficient land base to utilize phosphorus in manure, assuming 100% of cropland is suitable for application. It is impossible to accurately determine what percent of the cropland in each county falls into the 590 standard’s no spread zone, as accurate maps showing the locations of all prohibited features do not exist (private wells, sinkholes and direct groundwater conduits).

**Table 7. Phosphorus crop removal vs. phosphorus production from livestock (lbs)**

	Brown	Calumet	Manitowoc	Outagamie	Winnebago
P Crop Removal*	7,655,482	5,727,195	8,859,021	8,970,694	5,740,550
P Production from Livestock*	5,583,903	3,677,047	5,947,372	5,094,751	2,150,131
Net Gain/Loss*	-2,071,579	-2,050,148	-2,911,649	-3,875,943	-3,590,419

\*Phosphorus removed in the form of P2O5 – factor at .44

The only expense that needs to be accounted for in the scenario is the “relocation” of manure to maintain the phosphorus balance previously determined. A good example of the need for the distribution of manure evenly over the county can be seen in the Brown County permit map found in figure 2. This map doesn’t detail every dairy in the county but does illustrate variations in permit density. Another example for the northeast region of Wisconsin can be found in figure 3; this reflects density levels of CAFO dairies in northeastern Wisconsin. The estimated cost to transport one cow/replacement’s annual liquid manure production within a Wisconsin county is \$125/year/AU (Per conversation with Kevin Erb, May 2009.) The relocation expense can be calculated as follows:

$$\frac{\$125 \text{ (cost to move manure within the county 1AU)} \times \text{AU in the county} \times 20\%}{\text{Non forage acres}}$$

There is no expense allocated for incorporation of manure since this will occur regardless of management practices. Summary data on crop and livestock are provided in Tables 8 and 9. See Appendix B for detailed data tables for each county.

**Table 8. Acres of crop type by county**

	<b>Brown</b>	<b>Calumet</b>	<b>Manitowoc</b>	<b>Outagamie</b>	<b>Winnebago</b>
Corn (Grain)	34,900	33,000	43,700	72,200	45,500
Corn (Silage)	32,100	20,500	29,000	25,400	14,700
Wheat	14,800	10,900	16,800	10,000	14,700
All Forage	58,500	34,700	70,000	52,600	26,300
Soybeans	20,100	19,600	21,600	42,000	31,400
Oats	5,000	2,500	7,500	2,600	1,600
Barley			1,200		
Snap Beans			2,400		
Green Peas		1,300			
<b>Total Acres</b>	<b>165,400</b>	<b>122,500</b>	<b>192,200</b>	<b>204,800</b>	<b>134,200</b>

**Table 9. Livestock distribution (number of head)**

	<b>Brown</b>	<b>Calumet</b>	<b>Manitowoc</b>	<b>Outagamie</b>	<b>Winnebago</b>
Total Cattle & Calves	104,312	60,705	97,330	86,472	33,372
Lactating Cows	39,020	28,222	45,704	37,681	16,657
Replacements	39,020	28,222	45,704	37,681	16,657
Beef Cows	1,881	1,032	1,908	2,313	1,180
Beef Calves	1,693	929	1,718	2,084	1,063
<b>Remaining Difference **</b>	<b>22,698</b>	<b>2,300</b>	<b>2,296</b>	<b>7,079</b>	<b>2,185</b>

\*\* Steers and replacement heifers being raised

-These remaining animals are allocated evenly between the three calf and heifer categories

-Formal county by county break downs of the aforementioned are attached.

Figure 2. Brown County Animal Waste Management Ordinance Permits

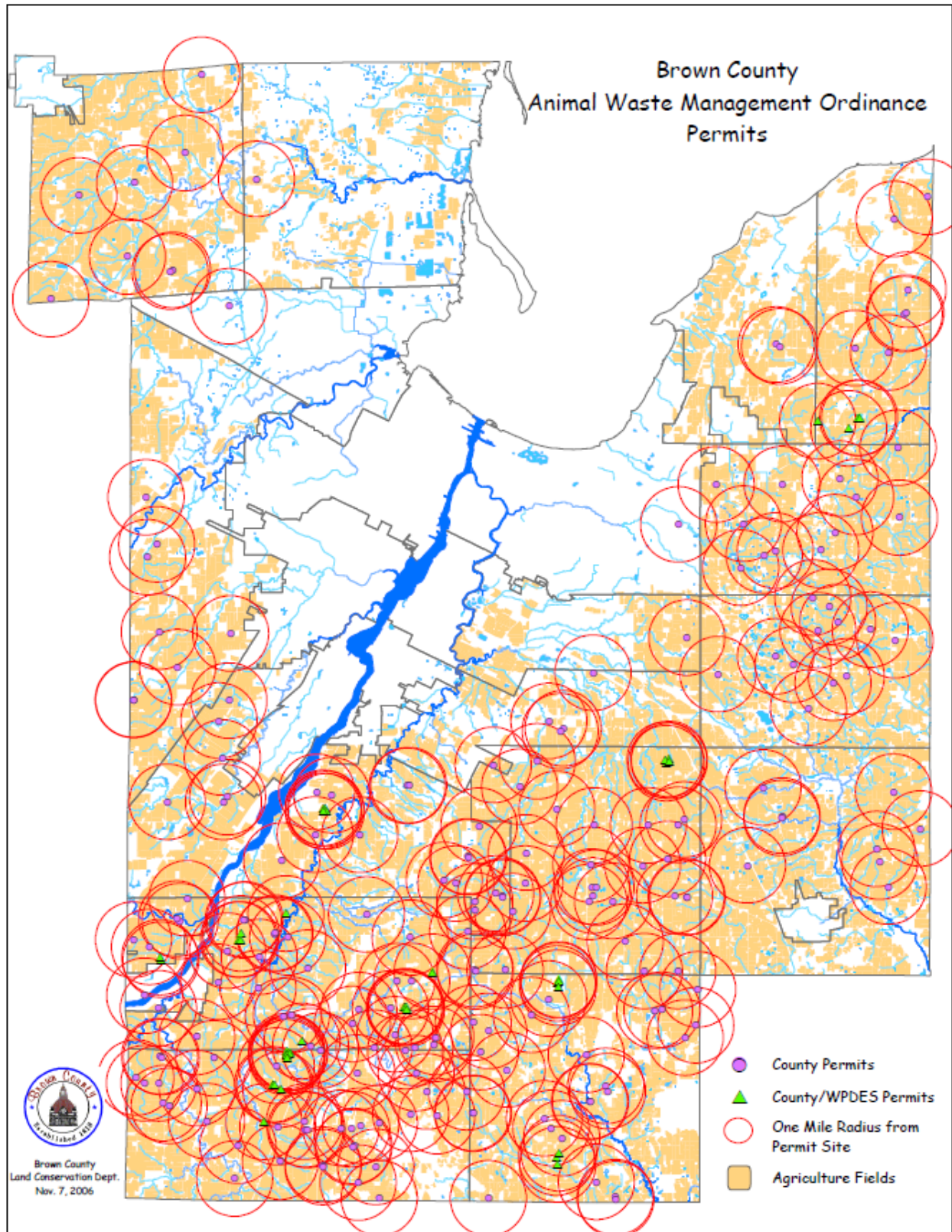
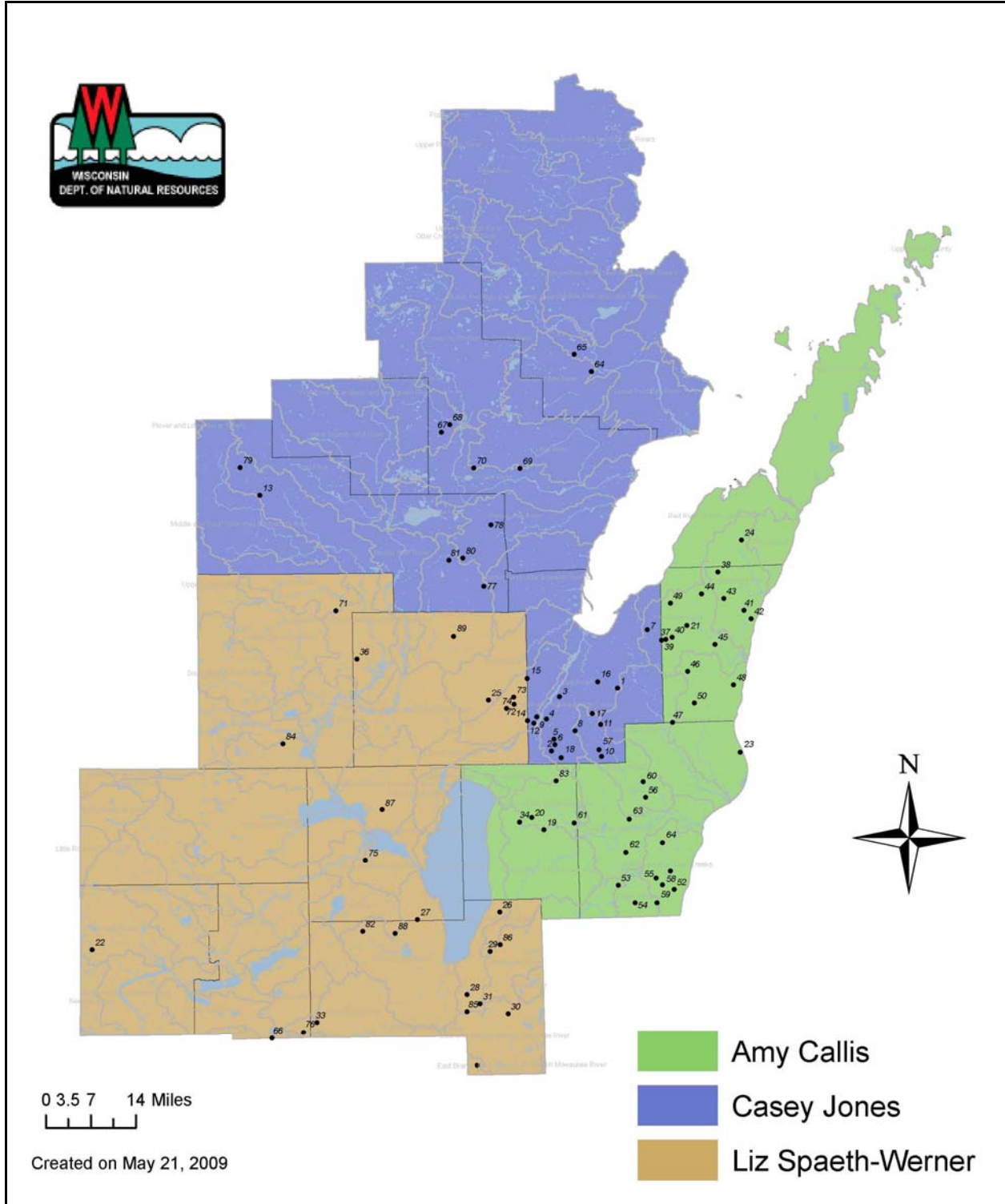


Figure 3. Northeast Regional CAFOs



#### **BMP #4 - Conservation Tillage (mulch tillage and zone tillage)**

When crop land is being prepared after harvest, plows are typically used to clear the field of residue or any growing vegetation (e.g., weeds, cover crop, etc.) from the previous season. With no crop residue or vegetation on the surface to restrict the lateral movements of water, plowed fields are highly vulnerable to erosion, with excess phosphorus and sediment transported to nearby surface waters. Conservation tillage systems are highly effective at reducing soil erosion and runoff volume. Conservation tillage is a term used to describe any system that leaves about a third of the soil covered up to and after the crop is planted. Both mulch till and zone till (two forms of conservation tillage) were considered as one of the scenarios for the analysis. Mulch till is a conservation tillage and planting system that disturbs the soil surface prior to planting but still leaves 30 percent or more of the soil surface covered by crop residue after planting. Zone till (or strip till) is a conservation tillage and planting system where the soil is left undisturbed from harvest to planting except for strips up to 1/3 of the row width. In general, zone-tillage should leave greater than 50 percent of the soil surface covered by crop residue after planting. Under this scenario, the area of land dedicated to conservation tillage (i.e., reduced tillage practices) is allowed to increase from the estimated 2004 baseline levels of 15.2% mulch till, 1.7% zone till, and 83.1 % conventional tillage, to a maximum of 60% of land under conservation tillage (i.e., mulch till or zone till), but not more than 15% under zone-till management. This assumes zone tillage after corn grain harvest; we do not want to imply 50% after silage or soybeans. The implementation cost of mulch tillage (\$15/acre) was based off the 2007 Wisconsin Custom Rate Guide, (Custom Rate Guide 2007). Zone tillage (\$20.50/acre) implementation cost estimates were based on personal conversations with an equipment dealer and farmer that are actively involved in the sales and use of this new technology, (Clark Riemer, Local Farmer; Randy Riesterer, Local Farm Equipment Supplier, personal communication, 2009).

## **BMP #5 - Cover Crops (on low residue fields)**

For this scenario, a cover crop of rye is planted after corn silage and soybean are harvested in the fall. This scenario is simulated in the following incremental steps: 1) All corn-silage fields (on the 36% of cropland planted to silage in a conservation tillage system); and 2) All corn-silage and soybean fields (maximum implementation of 72%). To limit the maximum practical implementation rate, this scenario is applied only to dairy crop rotations, although it could also be utilized for soybean grown within cash-crop rotations. A potential future modeling option may involve adding an additional set of hydrologic response units to allow a continuously variable proportion of cover crops. The cover crop scenario is only applied to fields under mulch tillage management because conventional tilled management is inconsistent with planting cover crops. However, fields under zone tillage management could benefit when corn-silage is in the rotation. The estimated cost of cover crops (\$61.63/acre) includes estimated costs for rye seed (\$12.00/acre), planting or drilling the seed (\$16.50/acre), cover crop kill with Roundup prior to planting (\$23.63/acre) and loss of production from planting delay (See Appendix C).

## **BMP #6 - Vegetative Buffer Strips**

Vegetative buffer strips (VBS), also known as vegetative filter strips, riparian buffer strips, or filter strips, can reduce sediment and phosphorus loading to nearby waterbodies. In this scenario, it is assumed that VBS are installed along 100% of all streams adjacent to crop land as delineated in the WDNR 1:24k hydrology Geographic Information Systems (GIS) data layer. Streams with existing VBS or that have "natural" VBS were included in the 2004 Baseline model simulation (Baumgart, 2005). It is important to note that there are many additional streams, drainage ditches, channels, and road ditches that are not delineated in the WDNR 1:24 k hydrology layer, which could also have VBS installed to improve water quality and riparian habitat.

The Conservation Reserve Enhancement Program (CREP) provides Wisconsin landowners an opportunity to voluntarily enroll agricultural lands into conservation practices such as VBS. Calculations for a typical CREP Equivalent payment can be seen in Appendix D. The estimated costs of VBS run from \$350 to \$4,000 an acre and include federal and state cost sharing, as well as additional state incentives. Brown County now has a county ordinance on the books requiring the implementation of VBS's. This requires 35 feet free of row crops on both sides of all blue lines found on USGS quadrangle maps. It should be noted that a majority of these are harvestable buffers (Bill Hafs, Brown County Land Conservation Department, personal communication, 2009). Other counties involved in this project have non-mandatory programs and participation tends to be lower. It was the opinion of the Land and Water Conservation departments that a higher cost should be used for this scenario if there was a hope of increasing participation rates in this management practice. The maximum potential cost of \$3,500 / acre was used for this analysis.

## **BMP #7 - Decrease Soil Phosphorus Levels from 40 ppm to 25 ppm (Bray PI)**

This modeled option requires lowering the average soil test phosphorus (Bray-1) from a current average of 40 ppm to 25 ppm. 25 ppm is considered the “optimal” level for the three primary crops grown in the watershed (alfalfa, corn grain, corn silage). When soil test levels are optimum, the annual fertilizer recommendation matches crop removal. At soil tests above optimum, the recommendation is a fraction (from zero to 50%) of crop removal.

The first step in this analysis requires calculating the crop removal (harvested portion) and the natural return cycling (manure applied) for each county, which creates a net gain/loss of phosphorus on a field basis (what is added to the field from manure minus what is removed in crop harvested). For each county in the watershed, several scenarios were run to determine how many years it would take to achieve the desired result. These included:

- Prohibiting the application of any fertilizer and any manure until average levels dropped to 25 ppm
- Prohibiting the application of manure and limiting the fertilizer to the minimum recommended application (100# of starter fertilizer in the row at planting)
- Allowing manure to be applied and limiting the fertilizer to the minimum recommended application. This practice is addressed in individual producer’s nutrient management plans.
- Allowing manure to be applied and prohibiting any starter fertilizer.

A calculator was developed to determine the soil test impact of exporting various percentages of manure to other cropland areas in the Midwest where the P is needed in order to reach the goal of 25ppm. The cost to move manure from the Lower Fox River Basin via semi truck and trailer to the central Sands region of Wisconsin was calculated to be \$267.20/AU (this does not include application costs). (Per conversation with Kevin Erb, May 2009.) The cost to move manure from Green Bay to Normal, IL (phosphorus deficient center of the corn belt) via rail tanker car was calculated to be .0921 cents per gallon (Per CN Gateway pricing) (this includes freight and local delivery charges). No further economic analysis were conducted on any of these options, as it is considered economically impossible to export any or all of the manure the required distance to meet any of these scenarios unless a technology is developed to remove and purify the majority of water in liquid manure. Table 10 contains summary information on the net loss of phosphorus under current crop removal and manure production, as well as the years required to reduce soil P from 40 ppm to 25 ppm. Please refer to Appendix F for detailed information on each county.

**Table 10. Phosphorus crop removal vs. phosphorus production from livestock**

	<b>Brown</b>	<b>Calumet</b>	<b>Manitowoc</b>	<b>Outagamie</b>	<b>Winnebago</b>
Corn (Grain)	34,900	33,000	43,700	72,200	45,500
Corn (Silage)	32,100	20,500	29,000	25,400	14,700
Wheat	14,800	10,900	16,800	10,000	14,700
All Forage	58,500	34,700	70,000	52,600	26,300
Soybeans	20,100	19,600	21,600	42,000	31,400
Oats	5,000	2,500	7,500	2,600	1,600
Barley			1,200		
Snap Beans			2,400		
Green Peas		1,300			
<b>Total Acres</b>	<b>165,400</b>	<b>122,500</b>	<b>192,200</b>	<b>204,800</b>	<b>134,200</b>
P Crop Removal (lbs)	7,655,482	5,727,195	8,859,021	9,515,810	5,740,550
P Production from Livestock (lbs)	5,583,903	3,677,047	5,947,372	5,094,751	2,150,131
Net Gain/Loss (lbs)	-2,071,579	-2,050,148	-2,911,649	-4,421,059	-3,590,419
Years from 40 ppm to 25 ppm 0% Exported	84.17	40.35	41.87	25.41	16.43
Years from 40 ppm to 25 ppm 10% Exported	41.0	27.86	28.29	20.59	14.97
Years from 40 ppm to 25 ppm 20% Exported	27.11	21.27	21.36	17.31	13.75
Years from 40 ppm to 25 ppm 30% Exported	20.24	17.2	17.16	14.93	12.71
Years from 40 ppm to 25 ppm 40% Exported	16.16	14.4	14.34	13.12	11.82
Years from 40 ppm to 25 ppm 50% Exported	13.44	12.44	12.32	11.71	11.04
Years from 40 ppm to 25 ppm 60% Exported	11.51	10.93	10.79	10.57	10.36
Years from 40 ppm to 25 ppm 70% Exported	10.06	9.75	9.61	9.63	9.76
Years from 40 ppm to 25 ppm 80% Exported	8.94	8.79	8.65	8.84	9.23
Years from 40 ppm to 25 ppm 90% Exported	8.04	8.01	7.87	8.18	8.75
Years from 40 ppm to 25 ppm 100% Exported	7.3	7.36	7.22	7.6	8.32

Phosphorus removed in the form of P<sub>2</sub>O<sub>5</sub> – factor at .44

**Interactive spreadsheets for these calculations can be found at:**

[http://www.co.brown.wi.us/departments/page\\_4b3351439d09/?department=68d3c3d55278&subdepartment=9207c5a3d3d5](http://www.co.brown.wi.us/departments/page_4b3351439d09/?department=68d3c3d55278&subdepartment=9207c5a3d3d5)

## **BMP #8 - Switchgrass added to typical cash-crop rotation of alternating years of soybean and corn-grain.**

Maximum implementation rate set at 7% of all agricultural land in the basin

Yearly prorated expenses on a per acre basis of \$363.51, yielding a per ton expense of \$90.88. A second year prorated expense of \$6.18 per acre will be required for over seeding to help establish/maintain the switchgrass stand. At the moment, the value of this commodity needs to be predicated on the value of good quality grass hay. Current market values reflect approximately \$75.00 per ton. In the state of Wisconsin, there are no viable options for incineration of switchgrass nor has the technology been adequately developed to utilize it for ethanol production.

Soil samples (nutrients and soil ph) and changes in fertilizer prices will play an important role in the cost of implementation of this scenario. The numbers cited parallel work being done on switch grass by Mark Renz at UW Madison.

The following assumptions will be relaxed later, but they are used for the illustration that follows:

- The switchgrass is frost-seeded with a 25 percent probability of needing to reseed the stand
- The land charge assumed is \$80 per acre – this is slightly lower than county averages
- Switchgrass yield is 4 tons per acre
- The switchgrass stand is assumed to last 11 years
- The reseed is assumed to last 10 years
- The interest rate used for prorating the establishment costs is 8 percent, while the operating interest rate is 9 percent
- Operating costs are assumed to be borrowed for six months
- The field is initially prepared by adding phosphorus and potassium. There is also an application of lime assumed. (In NE Wisconsin this may not be necessary)

See appendix E.

## BMP #9 - Water Sediment Control Basins

Water and sediment control basins are embankments, located in areas with concentrated runoff. The basins trap runoff water and sediment before they can reach a stream. Like grassed waterways, sediment basins must be periodically maintained and the accumulated topsoil spread back out over the fields. Table 11 provides a summary of WASC OB implementation costs. Appendix G contains the WASC OB design spreadsheets for each of the five options presented in Table 16. The TMDL and LCD team determined that an implementation rate of 1% should be applied due to the soil and geologic limitations that are frequently found in the Lower Fox River Basin.

**Table 11. WASC OB Implementation Costs**

Type	Size	Cost
Non Farmable Slopes*	5 acre	\$2,150
Non Farmable Slopes	10 acre	\$2,750
Down Stream Slope Farmable**	5 acre	\$2,478
Down Stream Slope Farmable	10 acre	\$3,358
Both Slopes Farmable	10 acre	\$3,965

\*Non-farmable slopes mean taking a small area of land out of production.

\*\*Farmable means that part of the structure is designed to allow crops to be planted on it, further reducing the land lost.

## **BMP #10 - Use of anionic polyacrylamide (PAM) to control runoff, soil erosion, and nutrient loss**

Agricultural activities often act to degrade soil properties such as aggregate stability, infiltration rate, and water-holding capacity due to mechanical disturbances, loss of organic matter, and lack of protective surface cover. Considerable research is being conducted on the use of soil amendments to stabilize or enhance the soil surface that is subjected to rainfall or runoff. In construction applications anionic PAM has been shown to be an effective material to help enhance infiltration, reduce runoff, reduce soil loss, and in some cases reduce nutrient losses from soil. Experimentation examining the use of PAM in land-applied livestock lagoon effluent as a means to reduce sediment and nutrient loss has shown potentially promising results. Field trials with PAM are being examined to evaluate its effectiveness in controlling erosion in newly-established grass waterway channels prior to establishment.

Currently Brown County, in conjunction with ENCAP and FEECO, are running field trials on urea impregnated with PAM. This is very new technology being utilized for agricultural applications. Due to patents pending, it is impossible to estimate rates of utilization for the cost of implementing this practice. The technical team felt that it was important to mention and investigate anionic polyacrylamide. As time passes and more details become available this technology may well fit into numerous agricultural BMP's. At the moment, due to inadequate information, this BMP will not be included in the optimization.

## References

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