Appendix B: Progress Assessed through Program Quantification

Program quantification is intended to provide an assessment of the recent progress that has been achieved, in terms of nitrogen and phosphorus load reduction, through documented implementation of best management practices (BMPs) and wastewater treatment adopted in direct response to government programs. Many of the nutrient reducing programs (see Chapter 4) contain numerous structural and non-structural BMPs implemented as part of these programs. Not all programs had data that were able to be translated into spatially quantified nutrient load reductions. Program quantification therefore only addresses those programs with applicable data on a HUC8 scale.

Program quantification included the following indicator BMP categories:

- Nutrient management (NRCS EQIP)
- Forage and biomass planting (NRCS EQIP)
- Residue management (NRCS EQIP)
- Conservation easements (BWSR Reinvest in Minnesota [RIM])
- Nonpoint source BMPs (as reported in BWSR's eLINK, not including feedlot BMPs)
- Septic system improvements (MPCA Subsurface Sewage Treatment System Program)
- Feedlot projects (MPCA Feedlot Program)
- Phosphorus lawn fertilizer ban

Data for nutrient management, forage and biomass planting, and residue management were obtained from the EQIP program, while data for conservation easements were obtained from the BWSR RIM program. Data for nonpoint source BMPs were provided through the eLINK system, maintained by BWSR. The eLINK system only tracks and reports phosphorus load reductions associated with BMPs. Total acres (by HUC8) were tabulated for each BMP category with the exception of the nonpoint source BMPs from eLINK, for which total load reduction data (lbs/year) were provided for each HUC8, for phosphorus only. Feedlot phosphorus load reductions are tracked separately in eLINK, and are reported separate from other nonpoint source BMPs in this section based on data from Open Lot Agreements tracked by the MPCA's Feedlot Program. Phosphorus reductions from septic system improvements were based on the estimated number of septic systems that had been identified as an

imminent threat to public health or safety (ITPHS) and had been brought into compliance. Reductions in phosphorus loading as a result of the statewide phosphorus fertilizer ban were compiled from various sources (Vlach et al. 2010, Lehman et al. 2009, and Schueler and Lane 2013); a 10 percent in phosphorus loading from urban areas was assumed.

Recent trends in point source loads (wastewater) were quantified based on SPARROW results. A more recent version of the SPARROW model is available which provides updated (2005–2006 for nitrogen and 2005–2009 for phosphorus) point source data. These updated results were compared to the original SPARROW results to calculate the relative percent change in phosphorus and nitrogen loading from point sources that has recently occurred.

Assumptions

A key assumption used in program quantification is that the SPARROW results approximate conditions prior to recent program efforts to increase BMP adoption. This assumption enables us to determine the loads reduced by existing BMPs by using SPARROW generated watershed loads combined with BMP load reduction efficiencies.

Cropland BMPs were applied to only the agricultural loads in SPARROW. SPARROW agricultural loads are the summed loads for manure, other agricultural sources, and atmospheric deposition (scaled by the proportion of the HUC8 that is agricultural).For phosphorus, it is important to note that approximately 15 percent of the load in the Mississippi River Basin is derived from streambank erosion (Barr Engineering 2004). SPARROW, however, does not separately account for streambank erosion as a source and the agricultural load portion of SPARROW accounts for both upland sources and sources associated with streambank erosion in agricultural areas. Accordingly, the phosphorus source allocation fraction estimated in the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) was applied to the HUC8 phosphorus loads from SPARROW to identify the load derived from upland agricultural sources.

Source load reductions may not yet be fully realized at the instream stations near the Minnesota state line, particularly for phosphorus, due to lags in transport through the stream network, but are expected to be achieved over time.

BMP removal efficiencies were assigned to each indicator cropland BMP based on recent literature review efforts by the MPCA, MDA, and Iowa State University (Table B-1). Removal efficiencies were selected from these efforts with a focus on studies in the Midwest, with Minnesota-based studies receiving the highest priority. Chapter 5 includes additional discussion on available literature sources.

Table B-1. BMP removal efficiencies (see Chapter 5 for further discussion)

Indicator BMP Category	Nitrogen Removal (%)	Phosphorus Removal (%)	Sources
Residue Management	0	63	Miller et al. 2012; Iowa State University 2013; Simpson and Weammert 2009
Nutrient Management	16	24	MPCA 2013a ; Iowa State University 2013
Forage and Biomass Planting	95	59	Iowa State University 2013; MPCA 2013a
Conservation Easements	83	56	Iowa State University 2013; MPCA 2004; MPCA 2013a

Reductions for miscellaneous sources apply to phosphorus only and include septic system improvements, feedlots, and the phosphorus lawn fertilizer ban. Reductions in phosphorus from septic systems was estimated using MPCA program data based on the number of ITPHSs that had been brought into compliance. The average total phosphorus production per capita (2.3 lbs phosphorus produced per capita per year) was estimated from a septic system's average flow (60 gallons per capita per day; Lowe 2009), the average phosphorus concentration of septic tank effluent (12.5 mg/l phosphorus; EPA 2002; Crites and Tchobanoglous 1998), and the average number of people per dwelling (2.46 people per dwelling; 2010 U.S. Census). The percentage of phosphorus that reaches surface waters from ITPHS and conforming systems (Table B-2; Barr Engineering 2004) was then used to estimate the reduction of phosphorus loading to surface waters as a result of the upgrades. Permanent and seasonal residences were both taken into account, and it was assumed that 16 percent of all dwellings in the state are seasonal. Between 2002 and 2013, an estimated 27,710 ITPHSs were brought into compliance. The SPARROW attenuation factors were applied to the load reduction estimates.

Table B-2. Percent of phosphorus from septic systems that reaches surface waters (from Barr Engineering 2004)

Description	Percent of phosphorus that reaches surface waters from septic systems (%)
Permanent residence, conforming system	10
Permanent residence, failing system	30
Permanent residence, imminent threat to public health system	43
Seasonal residence, conforming system	20
Seasonal residence, failing system	43
Seasonal residence, imminent threat to public health system	43

The Open Lot Agreement is a provision in the Feedlot Rule (7020) in which eligible livestock producers can receive an extended time for making improvements to open feedlots for water quality issues. Between 2000 and 2010, there was an average of 141 additional feedlot fixes per year from open lot agreements and other efforts to reduce feedlot runoff. Another 108 feedlot closings per year occurred, on average. A typical MinnFARM model annual load reduction of 25 pounds of phosphorus reduced per project was used to determine total phosphorous load reductions by major basin. Basin or smaller scale data were not available. This estimate does not include manure application to cropland related reductions stemming from rule revisions made in 2000 or voluntary changes for livestock feed which reduced phosphorus in manure.

A 10 percent reduction in phosphorus loading from urban areas was assumed to have occurred as a result of the statewide phosphorus fertilizer ban. The Chesapeake Stormwater Network estimated that statewide phosphorus fertilizer bans in the Chesapeake Bay watershed have led to a load reduction from the overall urban stormwater sector of approximately 10 percent (Schueler and Lane 2013). The authors found that their results were consistent with research in Minnesota (Vlach et al. 2010) and Michigan (Lehman et al. 2009 [1]). A 10 percent phosphorus load reduction was applied to the average loads from urban runoff in the *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004) to estimate the total load reductions that resulted from the phosphorus fertilizer ban.

The following key assumptions were also considered in the program quantification analysis:

- Existing BMPs are applied to mutually exclusive land areas. For example, nutrient management and residue management are not implemented on the same farms. In reality it is likely that these practices are implemented concurrently on the same fields.
- BMP efficiency is presumed to be the same for tiled versus non-tiled lands.

Cropland and Miscellaneous Source Results

Table B-3 and Table B-4 present a summary of non-wastewater program quantification results for nitrogen and phosphorus, respectively. The loads presented in these tables represent the loads generated within Minnesota by major basin or basin, delivered to the state line. The current conditions load presented in the tables (second column in each table) reflect the recent point source update to SPARROW.

[1] This study found higher percent reductions in a subset of the data. Their reported percent reductions (28%) represent an upper estimate of May through September monthly phosphorus concentration reductions in their study area.

The results of the program quantification analysis suggest that recent implementation of cropland BMPs has not achieved a significant nitrogen load reduction relative to conditions in 2000, as represented by SPARROW. For nitrogen, about a 1 percent reduction of nitrogen load statewide was estimated. For phosphorus, it appears that modest load reductions have recently been achieved (almost 8 percent reduction of the statewide phosphorus load).

Table B-3. Summary of recent progress for cropland nitrogen loads (total to state line)

Basin	Current Conditions N with Point Source Update (metric tons/ yr) [a]	N Reduced by Nutrient Mgmt. (metric tons/yr)	N Reduced by Forage and Biomass Planting (metric tons/yr)	N Reduced by Residue Mgmt. (metric tons/yr)	N Reduced by Conservation Easements (metric tons/yr)	Net N Reduction (metric tons/yr)	% of N Reduced by BMPs
Cedar River	6,918	16	1	0	53	70	1.0%
Des Moines River	4,507	36	1	0	36	73	1.6%
Lake Superior	3,656	0	0	0	0	0	0.0%
Mississippi River [b]	99,441	476	47	0	837	1,361	1.4%
Missouri River	5,208	34	3	0	16	52	1.0%
Rainy River	2,606	1	3	0	0	4	0.1%
Red River	16,822	90	30	0	40	159	0.9%
Total	**139,159**	**654**	**85**	**0**	**981**	**1,719**	**1.2%**

a. Loads calculated from SPARROW.

b. Loads for the Mississippi River basin are tabulated at De Soto, WI downstream of the MN/IA state line, using SPARROW.

Table B-4. Summary of recent progress for cropland and miscellaneous source phosphorus loads (total to state line)

Basin	Current Conditions P with Point Source Update (metric tons/yr) [a]	P Reduced by Nutrient Mgmt. (metric tons/yr)	P Reduced by Forage and Biomass Planting (metric tons/yr)	P Reduced by Residue Mgmt. (metric tons/yr)	P Reduced by Conservation Easements (metric tons/yr)	P Reduced by BMPs tracked in eLINK [c] (metric tons/yr)	P Reduced by Septic System BMPs (metric tons/yr)	P Reduced by Feedlot Projects (metric tons/yr)	P Reduced by Urban Fertilizer Ban (metric tons/yr)	Net P Reduction (metric tons/yr)	% of P Reduced by BMPs
Lake Superior	255	0	0	0	0	2	0.7	0.1	2.3	5	2%
Cedar River	242	0	0	1	1	3	0.6		0.4		
Des Moines River	251	1	0	1	1	7	0.6		0.2		
Mississippi River [b]	5,553	18	1	28	13	395	13		23.4		
Missouri River	290	1	0	1	0	11	0.7	30.5	0.2	556	9%
Rainy River	204	0	1	1	0	4	0.2		0.2		
Red River	949	4	0	6	1	28	1.3	0.7	1.1	49	4%
Total	**7,742**	**24**	**2**	**39**	**15**	**450**	**17**	**31**	**28**	**610**	**8%**

a. Loads calculated from SPARROW.

b. Loads for the Mississippi River basin are tabulated at De Soto, WI downstream of the MN/IA state line, using SPARROW.

c. eLINK loads do not include feedlot projects.

Wastewater Source Results

Table B-5 presents recent trends in wastewater point source loads. Point source data (as loads generated within Minnesota and transported to the state line) were summarized in two different SPARROW models representing progress between the early and late 2000s. These data do not reflect the most up-to-date monitoring information, but are adequate to quantify progress. The data contained in the SPARROW models were derived from point source discharge monitoring records. The difference in wastewater loads from 2002 and 2005–2006 for nitrogen and 2005–2009 for phosphorus were used to calculate the change in phosphorus and nitrogen loading from point sources that has recently occurred. In general, there have been treatment improvements (especially for phosphorus in the Minnesota River, part of the Mississippi Major Basin), but also offsetting increases in discharge volumes. Wastewater phosphorus reductions in the Mississippi River Major Basin account for a 24 percent reduction in monitored baseline loads.

Table B-5. Summary of recent trends in point sources

Major basin	Nitrogen		Phosphorus	
	Recent Change in Point Source (metric tons/yr)	Percent Change in Baseline Loads	Recent Change in Point Source (metric tons/yr)	Percent Change in Baseline Loads
Lake Superior	+411	+13%	+7	undetermined
Mississippi River	+1,492	+2%	-1,113	-24%
Lake Winnipeg	-55	0%	-4	-0.3%