Michigan's Wastewater Treatment Plants
Recycling Metrics

Prepared for

Michigan Department of Environmental Quality

Water Resources Division

By

michigan water environment association mwea the water quality people

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Transformation

The wastewater industry is undergoing changes that may be more profound than at any time in its history. Those changes will have a major impact on the industry and those who are a part of it.

In June 2015, Ed McCormick of Oakland, California, then president of the Water Environment Federation (WEF), spoke at the opening session of the annual conference of the Michigan Water Environment Association (MWEA), and talked about the Water Resource Utility of the Future included a vision for improved energy, nutrient, and solids recycling and recovery at wastewater treatment plants throughout the country.

This vision sparked an impassioned interest in Mr. William “Bill” Creal, then Chief of the Water Resources Division (WRD) of the Michigan Department of Environmental Quality (MDEQ), about the opportunities this could offer for communities in Michigan.

Later that year, Mr. Creal proposed, with the support of the Governor’s office and the head of DEQ, developing recycling metrics for the state’s wastewater treatment plants. The metrics focus on biosolids, nutrients (nitrogen and phosphorus), and energy resources. In late summer, WRD leadership invited the Michigan Water Environmental Association (MWEA) to review and comment on draft metrics. The metrics were reviewed and feedback was provided to WRD. The metrics were presented at the Michigan Water Environment Association (MWEA) Sustainable Energy Seminar on October 20, 2015.[1]

I invite you to take time to read and learn more about the background and development of the first metrics. After you do, I think you will agree that the work completed to date establishes an excellent foundation for the transformation of Michigan’s wastewater industry to Water Resource Utilities of the Future.

Peter V. Cavagnaro, P.E.
Lead Author/Editor: Michigan’s Wastewater Industry, Recycling Metrics

[1] Cavagnaro, P.V., “MDEQ Observations on Sustainability, Municipal Wastewater Recycling in Michigan – How Can We Measure?” Michigan Water Environment Association, Sustainable Energy Seminar, October 20. 2015.

Chapter 1: Introduction

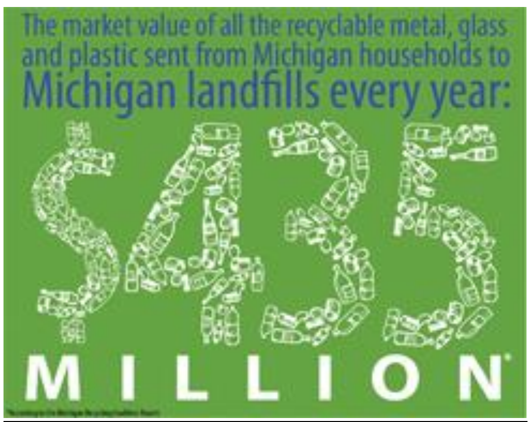
Introduction

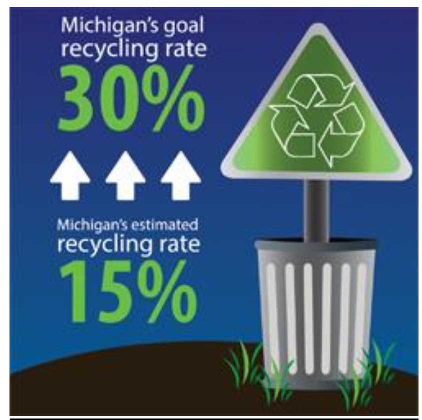
The following presents the efforts of Michigan DEQ's Water Resources Division (WRD), to develop "recycling" metrics for the state's Water Resource Recovery Facilities (WRRFs).

Background

In November 2012, Gov. Rick Snyder directed the DEQ to develop a plan to increase solid waste recycling. On April 14, 2014, the Governor announced a statewide plan designed to increase access for residential recycling from a baseline of 15 percent to a benchmark of 30 percent. His commitment to reduce the rate of solid waste disposal to the state's landfills has resulted in renewed interest in recycling.

Figure 1: State of Michigan Recycling Goals





http://www.michigan.gov/deq/0,4561,7-135-70153_69695-313206--,00.html

Recognizing the state's wastewater treatment plants handle a steady stream of waste and recycle a significant amount of solids and nutrients, William "Bill" Creal, Chief of the Water Resources Division (WRD) of the Michigan Department of Environmental Quality (MDEQ), approached MDEQ's and governor's offices about an initiative to monitor recycling efforts at the state's wastewater treatment plants. The response was supportive. It is a significant step in the MDEQ to sustain and maintain the investment in the state's WRRFs.

Table 1 shows similarities between landfills and wastewater treatment plants. Each accepts waste and generate biogas (if the wastewater treatment plant has an anaerobic digester(s)). However, there are significant differences. Recycling reduces the flow of waste and extends the life of landfills. Landfills rely on waste haulers to deliver the waste. But wastewater treatment plants have a steady flow of wastewater. In addition, a landfill is built, used, and closed. But a wastewater treatment plant is built, used, and renovated.

Table 1: Similarities between Landfills and Wastewater Treatment Plants

Landfills	Wastewater Treatment
Build it / Use it / Close it	Build it / Use it / Renovate
Haulers bring waste to the landfill	Steady, predictable source of waste
Generates biogas	Potential to generate biogas
Recycling extends life of landfill	Recycling uses nutrients, organics, and moisture

The historical role for wastewater utilities was to be protector of public health and protector of the environment. However, the world view is changing. On October 14, 2011,[2] the Water Environment Federation (WEF) published a position statement, Renewable Energy Generation from Wastewater. It noted:

> *WEF believes that wastewater treatment plants are not waste disposal facilities, but rather water resource recovery facilities that produce clean water, recover nutrients (such as phosphorus and nitrogen), and have the potential to reduce the nation's dependence upon fossil fuel through the production and use of renewable energy.*
>
> *The energy generated at water resource recovery facilities derived from the facility inputs should be considered as renewable energy because: Wherever people live, there will be human and organic waste (sewage, septage, food waste, restaurant grease, etc.) with biogenic carbon that can be converted to energy, as well as nitrogen and phosphorus nutrients that can be recovered.*
>
> *With the energy contained in wastewater and biosolids greater than the energy required for treatment, water resource recovery facilities have the potential to be energy neutral or even net energy producers, and some plants have already achieved that status. Reaching the goal of energy neutrality relies upon achieving a holistic energy management approach, incorporating conservation practices and generating renewable energy through the management of water resource recovery and its by-products.*

The Michigan Water Environment Association adopted the term Water Resource Recovery Facility in place of wastewater treatment plant and other conventional names. The name change reflects the direction of the industry in focusing on resource recovery.

In April 2015, an interagency work group composed of the NSF, DOE, and EPA published a report on an Energy-Positive Water Resource Recovery Workshop. That report stated, "As water treatment facilities, pipes, and related infrastructure in cities around the country approach the end of their expected service life, a unique window of opportunity exists to replace the aging

[2] Water Environment Federation Position Statement, Renewable Energy Generation from Wastewater, Adopted by Water Environment Federation (WEF) Board of Trustees: October 14, 2011

infrastructure with the *WRRF of the Future*—reducing stress on energy systems, decreasing air and water pollution, building resiliency, and driving local economic activity."

Several elements of Water Resource Recovery are in progress today in Michigan:

- Michigan Biosolids Program
- Great Lakes Water Authority biosolids dryer facility
- Grand Valley Regional Biosolids Authority
- City of Grandville, Michigan Egg Shaped Digesters
- City of Midland, Michigan digester gas to energy
- City of Flint, Michigan
- Delhi Township, Michigan

Metrics – How can we Measure?

In late summer, WRD leadership invited the Michigan Water Environmental Association (MWEA) to review and comment on draft recycling metrics for wastewater treatment plants (Appendix 2). The metrics, reviewed with feedback provided to WRD, were presented at the Michigan Water Environment Association (MWEA) Sustainable Energy Seminar on October 20, 2015.

Implementation of recycling metrics at Michigan's WRRFs was the first step towards establishing a Michigan Water Resources Utilities of the Future roadmap for conservation, recovery, and/or recycling of these resources.

Metrics were selected based on:

- Relevance to the "recycling" efforts within Michigan to increase beneficial reuse of biosolids.
- Relevance to the resources that may be recovered at a water resource recovery facility (nutrients and energy).
- Availability of existing information to establish baselines.

Initial Metrics selected for the State of Michigan were:

- Solids – Assess the disposition of biosolids whether by biosolids land application, landfill, incineration, or other.
- Nitrogen and Phosphorus – Assesses the amount of nitrogen and phosphorus entering the plant and the amount applied to land as part of biosolids land application. Likewise for nitrogen.
- Energy – How much energy is used to treat wastewater in Michigan and how is it used?

Baselines and Benchmarks

A baseline establishes the current level of activity and is usually measured over a period of at least 12 months. The 12-month period can be for either a calendar, reporting, or fiscal year.

A benchmark is target level of consumption, or performance that is established, or based on an analysis of the "best in class" facilities of the same type.

Basis of Analysis

Data available for this analysis was based on compliance reports received by MDEQ. WWTPs report on parameters contained in the discharge permit. This information represents the amount of material leaving the plant in the treated effluent. Information on the amount of material entering the plant for treatment is not readily available. Therefore, assumptions needed to be made on which to base the analysis. These are clearly stated in each of the following chapters.

Chapter 2: Solids

The process of treating wastewater results in the generation of solids requiring disposal, that may be disposed by:

- Dewatering the liquid sludge to a wet cake and disposed in a landfill.
- Dewatering and incineration of the cake with disposal of ash to landfill.

There are a number of options for recycling the solids including:

- Application of liquid sludge to agricultural land.
- Application of dewatered sludge to agricultural land.
- Dewatering followed by composting, and use of the resulting product.
- Dewatering of the liquid sludge to a wet cake followed by drying, and use of the resulting product.

There is a wealth of information available for the handling of biosolids. Information for assessing the recycling of solids is available from data in the Consolidated Statewide Biosolids Annual Report Forms. Records are available from fiscal years 1997 to 2015. Records up to 2010 are readily available on the state's website[3]. Review of the records for 1997-2010 indicates that the average production for each of these years is consistent.

Solids Recycling Baseline

The biosolids baseline was established with information contained in the Consolidated Statewide Biosolids Annual Report. The annual report includes accounting of biosolids generated, land applied, and disposed of by other means. There is currently very little composting of biosolids under way in Michigan, and the amount of solids composted is accounted for as part of the amount that is land applied.

The baseline was established by determining the amount of solids that were disposed in landfill and by incineration compared to other methods of disposal. The amount of "recycling" that was practiced was then determined by the percent of total solids that were land applied as biosolids or processed for other reuse applications (e.g., Detroit BDF project, compost, etc.) as compared to the amount that were landfilled and incinerated.

The numbers reported herein are order of magnitude estimates. The analyses were performed to develop an idea as to where the state's wastewater treatment plants are and to establish where they want to go. The values will change as additional information is collected and methods of analysis are refined. Assumptions used to generate the initial estimates are listed and are important to note.

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[3] http://www.michigan.gov/documents/deq/deq-water-biosolids-COMPARISON_BY_YEAR_251549_7.xls

Table 1: Summary of Solids Recycling at Michigan WWTPs

Description	units	2014	2015
Land Applied (a)	dry tons/year	80,897	75,845
Composted	dry tons/year	0 (b)	0 (b)
Landfilled	dry tons/year	135,622	123,681
Incinerated	dry tons/year	120,995	106,453
Total Disposed	dry tons/year	337,514	305,979
Percent removal of solids via treatment		90%	90%
Total Solids entering the treatment process		375,016	339,977
Total Biosolids Recycled (c)	dry tons/year	80,897	75,845
2014 Est. % Biosolids Recycled =		22%	22%

(a) The values include the very small amount of composting that is conducted in Michigan.

(b) Technically, there is some composting of biosolids in Michigan, but the amount is very small and the numbers are not monitored separately.

(c) Total Biosolids Recycled is the sum of Total Biosolids Land Applied and Total Biosolids Composted

Solids Recycling Benchmark

In keeping with the goals set by the Governor's Solid Waste Task Force, it is recommended that a preliminary goal be set to reduce the amount of solids sent to landfills by 50%. This preliminary goal might appear to be ambitious. An investigation was conducted to assess how this goal compared to other states. [4]

- 60% of all biosolids generated are beneficially reused nationally.
- Oregon land applies 95% of biosolids.
- Washington State land applies 81%.
- California land applies 70%.
- New York reports that 30% of biosolids are beneficially reused[5].

[4] http://www.ecy.wa.gov/programs/swfa/biosolids/faq.html
[5] http://www.dec.ny.gov/chemical/97463.html

Impact of the GLWA[6] Biosolids Dryer Facility

The GLWA biosolids dryer facility (BDF) in Detroit began operations in 2015. It is expected to process half the biosolids produced at that facility and will have a significant impact on recycling rates.

Table 2: Summary of Solids Recycling at Michigan WWTPs with Great Lakes Water Authority Biosolids Dryer Facility Online

Description	units	2014	2015
Total Solids Disposed	dry tons/year	337,514	305,979
Attributed to Great Lakes Water Authority	dry tons/year	162,000	147,000
Expected solids to Biosolids Dryer Facility	dry tons/year	81,000	73,500
Total Biosolids Recycled Today	dry tons/year	80,897	75,845
Total Biosolids Recycled with BDF	dry tons/year	161,897	149,345
2014 / 2015 Est. % Biosolids Recycled with BDF		43%	44%

Note: The Detroit facility treats an average flow of 660 MGD, or 48% of the total flow.

Summary

The solids going to the GLWA BDF would primarily have gone to landfill and incineration, a relatively small portion may go to land application. This represents an estimated doubling of solids to some form of land application or non-landfill or incineration disposal within the next 1 to 2 years.

[6] Great Lakes Water Authority

Chapter 3: Nutrients/Nitrogen

Nitrogen Recycling Baseline

Nitrogen may be present in several forms, and total nitrogen is the sum of organic nitrogen, ammonia (NH3), ammonium (NH4), reduced nitrogen (N), nitrite (NO2), and nitrate (NO3). The most prevalent forms in raw wastewater are organic nitrogen and ammonia (or ammonium). Total Kjeldahl nitrogen (TKN) is the sum of organic nitrogen and ammonia (or ammonium) nitrogen, and was as the parameter for computing the nitrogen load to Michigan's municipal WWTPs. The influent TKN concentration was estimated to be 25 mg/l.

The amount recycled was based on an estimate of the amount of nitrogen contained in the solids applied to land. The estimates of nitrogen beneficially reused are presented in Table 3.

Table 3: Summary of Nitrogen Recycling at Michigan WWTPs

Parameter	Units	2014	2015
Influent TKN (est.)	mg/L	25	25
Annual Municipal WWTP Flow	MGD	1,364	1,364
Nitrogen loading to municipal WWTPs	tons/year	51,902	51,902
Total Biosolids Land Applied	dry tons/year	80,897	75,845
Nitrogen (N, % of TS) from 2014 Data statewide averages		3.8%	3.8%
Estimate of nitrogen applied to land	dry tons/year	3,074	2,882
Estimate of Nitrogen Recycled (before adjustment)		5.9%	5.6%
Percent removal of solids via treatment process		90%	90%
Est. Annual Nitrogen Recycled		5.3%	5.0%

Nitrogen Recycling Benchmark

In keeping with the goals set by the Governor's Solid Waste Task Force, it is recommended that a preliminary goal be set to double the amount of nitrogen that is recycled.

Impact of the GLWA Biosolids Dryer Facility

The GLWA biosolids dryer facility (BDF) in Detroit began operations in 2015. It is expected to process half the biosolids produced at that facility and will have a significant impact on recycling rates.

Table 4: *Summary of Nitrogen Recycling at Michigan WWTPs with Great Lakes Water Authority Biosolids Dryer Facility Online*

Parameter	Units	2014	2015
GLWA BDF	dry tons/day	315	315
	dry tons/year	114,975	114,975
Total Biosolids Land Applied with GLWA BDF	dry tons/day	195,872	190,820
Nitrogen (N, % of TS) from 2014 Data statewide averages		3.8%	3.8%
Est. Annual Nitrogen Land Applied	dry tons/year	7,443	7,251
Est. Annual Nitrogen Recycled (before adjustment)		14.3%	14.0%
Percent removal of solids via treatment process		90%	90%
Est. Annual Nitrogen Recycled		12.9%	12.6%

Summary

This represents an estimated doubling of nitrogen to some form of land application within the next 1 to 2 years.

Chapter 4: Nutrients/Phosphorus

Phosphorus Recycling Baseline

The amount of phosphorus entering municipal WWTPs was estimated based on an influent (incoming) concentration of total phosphorus of 5 mg/l.

The amount recycled was based on an estimate of the amount of phosphorus contained in the solids applied to land. The estimates of phosphorus beneficially reused are presented in Table 5.

Table 5: Phosphorus Recycling at Michigan WWTPs

Parameter	**Units**	2014	2015
Influent Phosphorus (P)	mg/l	5	5
Municipal WWTP Flow	MGD	1,364	1,364
Municipal WWTP phosphorus loading	tons/year	10,380	10,380
Biosolids applied to land	dry tons/year	80,897	75,845
Phosphorus (% of TS)		1.9%	1.9%
Est. Annual Phosphorus Land Applied	dry tons/year	1,537	1,441
Est. Annual Phosphorus Recycled (before adjustment)		14.8%	13.9%
Percent removal of solids via treatment process		90%	90%
Phosphorus Recycled		13.3%	12.5%

Phosphorus Recycling Benchmark

In keeping with the goals set by the Governor’s Solid Waste Task Force, it is recommended that a preliminary goal be set to double the amount of phosphorus that is recycled.

Impact of the GLWA Biosolids Dryer Facility

The GLWA biosolids dryer facility (BDF) in Detroit began operations in 2015. It is expected to process half the biosolids produced at that facility and will have a significant impact on recycling rates.

Table 6: Phosphorus Recycling at Michigan WWTPs with Great Lakes Water Authority Biosolids Dryer Facility Online

Parameter	Units	2014	2015
Estimate with GLWA BDF (Order of Magnitude):			
GLWA BDF	dry tons/day	315	315
	dry tons/year	114,975	114,975
Total Biosolids Land Applied with GLWA BDF	dry tons/day	195,872	190,820
Phosphorus (P, % of TS) from 2014 Data statewide averages		1.9%	1.9%
Est. Annual Phosphorus Land Applied	dry tons/year	3,772	3,772
Est. Annual Phosphorus Recycled (before adjustment)		35.9%	34.9%
Percent removal of solids via treatment process		90%	90%
Est. Annual Phosphorus Recycled		32.3%	31.4%

- Fate of P in wastewater treatment process is relatively stable.
- Using actual biosolids annual report data…back-calculate to determine influent P load shows that P load estimates are ~20-25% high.
- One hurdle is that not all plants monitor for nutrients in the influent….

Summary

This represents an estimated doubling of nitrogen to some form of land application within the next 1 to 2 years.

Chapter 5: Energy

Electric Energy Baseline

An energy baseline consists of 12 months of bills for the specific utility in question: electric, natural gas, etc. At least two wastewater treatment plants in the state of Michigan purchase high purity oxygen from an outside vendor. If not purchased from an outside vendor, the oxygen would have to be produced on-site, resulting in a significant increase in energy consumption. An additional baseline is needed at these plants for the amount and cost of oxygen purchased.

There is no ready source of information for the amount of energy used by all Michigan's WWTPs. Some plants record the information on monthly operating reports. Once submitted as part of the monthly reports, these records are no longer kept at MDEQ, remaining at the treatment plant site. It is not known which plants record energy information on their operating reports. Information regarding power demand and consumption also resides in utility databases. However, this data has not been analyzed and is not available without the permission of the individual municipalities.

Without direct access to data, an attempt was made to make an "Order of Magnitude" estimate of the amount of electric energy used to treat wastewater in Michigan. In 2015, the baseline was estimated using wastewater flow for Michigan's municipal wastewater treatment plants as reported in the 2012 Clean Watershed Needs Survey (CWNS), and an estimated energy intensity of 2,300 kWh/MG treated. The resulting estimate was 1,007,000 MWh of electric energy consumed.

During 2015 and early 2016, a survey of select plants was conducted. The study, its results, and analysis are reported in a document titled "Energy Survey and Estimate of Energy Baseline". The estimated baseline to 1,056,000 MWh of electricity consumption.

It is recommended that the baseline be refined further by requiring monthly reporting of energy demand and consumption. If DEQ does not have the authority to collect this information, then an effort is needed to pass legislation granting that authority to access it.

Table 7: Summary of Energy Baseline for Michigan WWTPs

		2015 est of 2014 Baseline	2016 est of 2014 Baseline
State of Michigan ADF	MGD	1,200	1,364
Energy per year	MWh/yr	1,007,400	1,056,000

Electric Energy Benchmark

As with the other metrics, it is recommended to establish a preliminary goal of reducing the amount of electric energy purchased by 50%. The metric will be measured as the amount of energy consumed in MWhs. This may or may not result in a corresponding decrease in the cost for the electricity. For wastewater treatment plants, this will be achieved by a combination of energy conservation, energy production, and energy recovery.

Chapter 6: Additional Metrics

Food Waste

There is a synergy with wastewater treatment plants by co digestion in anaerobic digesters or co-composting facilities at Michigan WRRFs.

This waste could be gathered by the treatment facilities for grinding, mixing, and introduction into the treatment plant's digesters for additional fuel – perhaps future energy production.

The Governor's Recycling Council has identified separation of food waste from the solid waste stream as a major goal.

The USDA and EPA announced on September 16 the goal to reduce food waste by 50%.[7]

The amount of food waste processed at wastewater treatment plants should be monitored in the future.

Carbon

Carbon is critical to reclaiming energy. It is important to move carbon (present as organic material) in the raw wastewater to an anaerobic digester where it can be converted into methane. If the carbon (BOD) goes to aerobic treatment, it is lost as CO_2 or to the solids. There is a need to track carbon to produce methane in the digesters. Carbon that is not captured and converted to energy is a lost resource.

Nutrients

- ✓ The pathway of phosphorus through the treatment process is relatively straightforward – what comes in leaves with the sludge or in the effluent. If sludge goes to landfill or incineration, the phosphorus is lost forever. If to land application, it is recycled.
- ✓ The pathway for Nitrogen is complex given the transformations possible within the treatment process.
- ✓ Work is required to relate the nutrient load to the plant size.
- ✓ A possible micro-nutrients to monitor is magnesium.
- ✓ Investigation is needed of other means for reuse of nutrients in wastewater effluent

Water

- ✓ Reuse for agriculture, commercial irrigation, etc.[8]
- ✓ Water as a renewable resource – at the present time, all wastewater is discharged to the surface waters of the state.

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[7] http://www.usda.gov/wps/portal/usda/usdahome?contentid=2015/09/0257.xml&navid=NEWS_RELEASE&navtype=RT&parentnav=LATEST_RELEASES&edeployment_action=retrievecontent

[8] https://www3.epa.gov/region9/water/recycling/index.html

Economic Metrics (related to the Triple Bottom Line)

- ✓ Determine value of phosphorus and nitrogen coming into WWTPs.
- ✓ Establish financial metrics that reflect upon sustainability.
- ✓ Examine energy rate structures.

Environmental Metrics

- ✓ Consider environmental metrics.
- ✓ Determine how solids that accumulate in wastewater treatment lagoons are to be measured.

Appendix 1: Abbreviations

CCP	Composite Correction Program
LIFT	Leaders Innovation Forum for Technology
MDEQ	Michigan Department of Environmental Quality
MGD	Million Gallons per Day
MPSC	Michigan Public Service Commission
MWEA	Michigan Water Environment Association
NACWA	National Association of Clean Water Agencies
OCWA	Ontario Clean Water Agency
PPP or P3	Public-Private Partnerships
UBN	Utility Branding Network
UOTF	Water Resources Utility of the Future [Note to reader: this abbreviation is consistent with NACWA's abbreviation of the phrase]
EPA	Environmental Protection Agency
WEF	Water Environment Federation
WERF	Water Environment Research Foundation
WE&RF	Water Environment & Reuse Foundation
WRD	Water Resources Division
WRRF	Water Resource Recovery Facility
WWTP	Wastewater Treatment Plant