Metadata worksheets for 2018 Clean Water Fund Performance Report

The following metadata worksheets provide detailed information on each of the 25 performance measures and the external drivers presented in the "Clean Water Fund Performance Report," covering fiscal years 2016-2017. Each metadata worksheet includes measure background, methodology used, target or goal, supporting data, caveats and limitations, staff contacts and other useful information. The metadata serves as the foundation for the performance measures and provide documentation necessary to collect consistent and accurate data for the measures over time.

Investment measures

Surface water quality measures

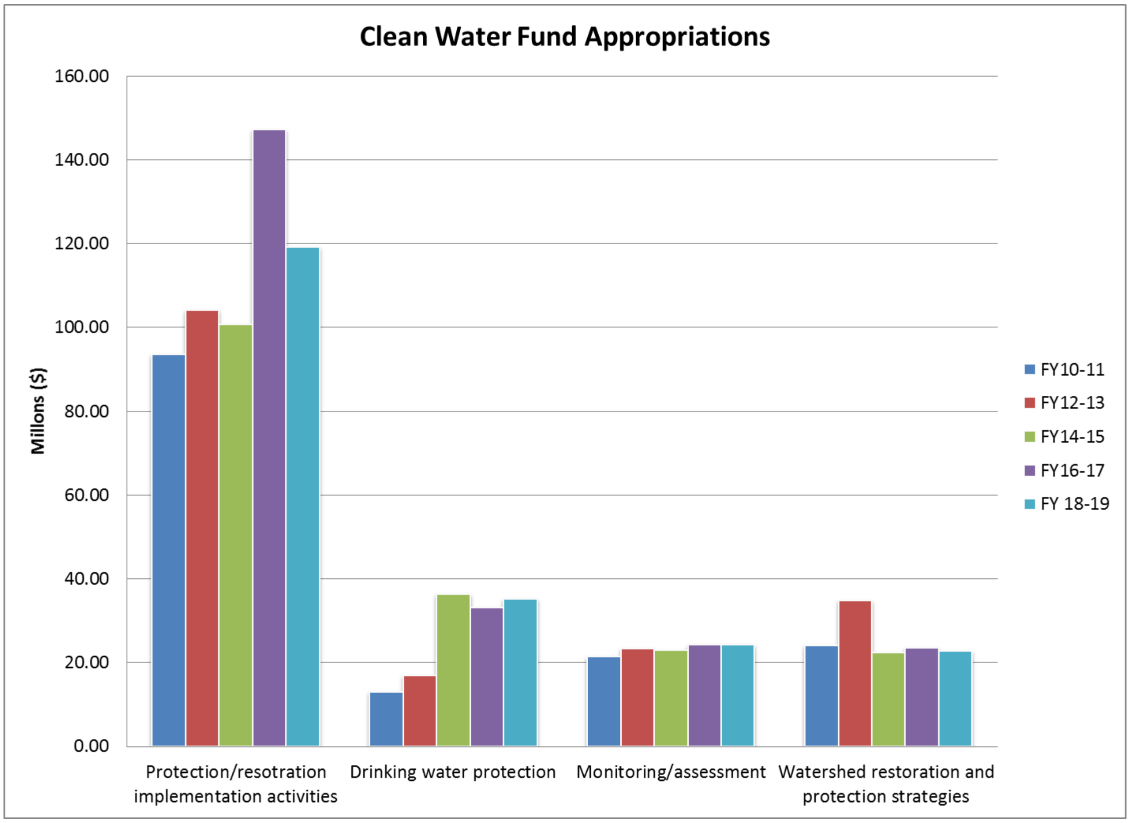
Drinking and groundwater measures

External drivers and social measures

Total Clean Water Fund dollars appropriated by activity

Measure Background

Visual Depiction



Measure Description

This measure communicates the overall amount of Clean Water Legacy Act funding allocated in a particular year and provides a break-down of that funding in specific categories to demonstrate funding trends over time. This measure provides context for the other financial measures and can be tracked in future years to determine overall appropriation trends. It is the primary investment that enables resources to be spent on the actions that will ultimately help achieve outcomes.

Associated Terms and Phrases

Drinking water protection includes:

- *Source water protection strategies*: Wellhead protection, source water assessment, and surface water intake protection activities that protect water from streams, rivers, lakes, or aquifers that is used for drinking.
- *Water supply planning:* Activities to maintain a safe and sustainable water supply, including the development of local public water supply plans, regional water supply plans, and groundwater management area plans.

Groundwater: The water beneath the land surface that fills the spaces in rock and sediment. It is replenished by precipitation. Groundwater occurs everywhere in Minnesota and supplies about 75 percent of Minnesota's drinking water and nearly 90 percent of the water used for agricultural irrigation. Groundwater also discharges to surface water and allows streams to flow beyond rain and snowmelt periods and sustains lake levels during dry spells.

Protection/restoration implementation includes:

- *Restoration implementation activities*: Implementation of best management practices, improved sewage treatment or other pollution reduction measures to bring an impaired waterbody into attainment with water quality standards. These activities are often funded in response to an approved Total Maximum Daily Load study (TMDL) that determines how much pollution needs to be reduced in order to achieve water quality standards.
- *Protection implementation activities*: Implementation of best management practices to prevent degradation and/or improve waterbodies or aquifers currently meeting water quality standards.

Monitoring and assessment includes:

- *Condition monitoring* – Monitoring consistently throughout the open water season with the objective of assessing the ambient, or background, condition of a lake or stream reach. Results are compared against water quality standards to determine if designated uses are supported.
- *Load monitoring* - Flow and chemistry monitoring conducted at the mouth (or outlet) of each major watershed. Monitoring is conducted at least monthly, and more frequently during events (i.e., snowmelt or rain events). The objective of load monitoring is to capture the entire hydrograph (or variation in the amount of water flowing past a location per unit time), and to determine the pollutant load carried by a stream or river. Results are compared against water quality standards to determine if designated uses are supported.
- *Problem investigation monitoring* – Monitoring with the objective of supporting water quality goals, often in cooperation with other interested agencies. May be conducted in response to accidental wastewater spills or discharges that may affect surface waters. Results are compared against water quality standards to determine if designated uses are supported.
- *Surface Water Assessment Grant (SWAG):* An MPCA grant that passes through funding to local partners for the purpose of conducting condition monitoring. Results are compared against water quality standards to determine if designated uses are supported.
- *Groundwater level monitoring* – Monitoring with the objective of collecting baseline data on groundwater level fluctuations and trends in local and regional aquifers.
- *Groundwater quality monitoring* – Monitoring with the objective of collecting baseline data on groundwater chemistry fluctuations and trends in local and regional aquifers.

Watershed: The surrounding land area that drains into a lake, river or river system. The watershed size used for this measure is at the "major watershed" scale. There are 81 major watersheds in Minnesota.

Watershed restoration and protection strategies includes:

- Applied research and tool development
- *Restoration strategies*: Planning activities to restore waterbodies not meeting water quality standards ("impaired"), including the development of a Total Maximum Daily Load study (TMDL) for an impaired water. A "TMDL" means a scientific study that contains a calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are restored and maintained. It results in pollution reduction goals for all sources of a pollutant in a watershed.

- *Protection strategies*: Planning activities to protect high quality ground and surface waters that are currently achieving water quality standards.

Target
There is no specific numeric target for this measure to date. A numeric target for this measure may be appropriate after funding trends over time are established.

Baseline
FY 10-11 serves as the baseline for this measure.

Geographical Coverage
Statewide

Data and Methodology

Methodology for Measure Calculation
The information for this measure is calculated every biennium according to appropriations for each major category.

Data Source
The data for this measure are provided by the Clean Water Fund Interagency Team following biennial appropriations. FY 2018-2019 data was obtained from Clean Water Council support staff to ensure that data used for this report was consistent.

Data Collection Period
Data for this measure span fiscal year (FY) 2010-2011, 2012-2013, 2014-2015, 2016-17, and 2018-2019.

Supporting Data Set

The following data table below was used to develop the graphic in the "Visual Interpretation" section of this metadata sheet.

Clean Water Fund Appropriations by Category (in Millions $)	FY 10-11	FY 12-13	FY 14-15	FY 16-17	FY 18-19	Total FY 10-19
Protection/restoration implementation activities	93.5	104.1	100.7	147.3	119.2	**564.8**
Drinking water protection	13.0	17.0	36.3	33.2	35.1	**134.6**
Monitoring/assessment	21.5	23.4	23.0	24.3	24.3	**116.5**
Watershed restoration and protection strategies	24.2	34.9	22.5	23.5	22.8	**127.9**
Totals By Category	**152.2**	**179.4**	**182.5**	**228.3**	**201.4**	**943.8**

Caveats and Limitations
None at this time.

Future Improvements
None at this time.

Financial Considerations

Contributing Agencies and Funding Sources
Funding displayed in this measure are for the programs and activities of the Minnesota Pollution Control Agency, Board of Water and Soil Resources, Department of Natural Resources, Department of Health, Department of Agriculture and Public Facilities Authority. These agencies also direct funding to a myriad of local government and nonprofit agencies.

Communication Strategy

Target Audience
Stakeholders with interest in this measure include the State legislature, the Clean Water Council, and state agency partners.

Associated Messages
This measure is intended to demonstrate a focus on funding implementation activities. Although there are no numeric targets for this measure, the trend should demonstrate a majority of CWF funding going to implementation activities.

Outreach Format
The principle outreach format for this measure is on the websites of state agencies and possibly the Legislative Coordinating Commission's site.

Other Measure Connections
This measure doesn't explicitly link to other measures, but does help to shed light on what types of projects are receiving funding, which affects progress in under other measure categories. In other words, this measure shows the source of much "inputs" for the "output" and "outcome" measures.

Measure Points of Contact

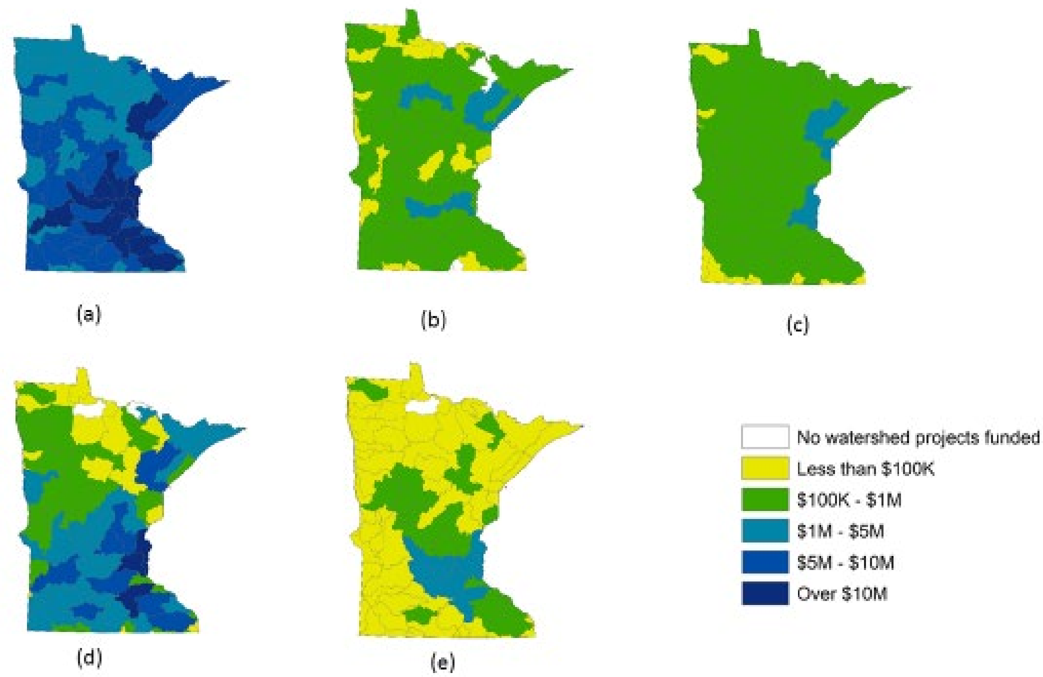
- BWSR contact: Matt Drewitz, matt.drewitz@state.mn.us
- DNR contact: Barbara Weisman, barbara.weisman@state.mn.us
- MDA contact: Margaret Wagner, margaret.wagner@state.mn.us
- MDH contact: Tannie Eshenaur, tannie.eshenaur@state.mn.us
- MPCA contact:
  - Monitoring and assessment – Pam Anderson, pam.anderson@state.mn.us
  - Watershed restoration and strategy development – David Miller (TMDLs, CWP), david.l.miller@state.mn.us
  - Bill Dunn (wastewater/storm water), bill.dunn@state.mn.us
- PFA contact: Jeff Freeman, jeff.freeman@state.mn.us
- Metropolitan Council contact: Lanya Ross, lanya.ross@metc.state.mn.us

Total dollars allocated per watershed or statewide to: 1) monitoring/assessment, 2) watershed restoration/protection strategies, 3) protection/restoration implementation activities, and 4) drinking water protection

Measure Background

Visual Depiction

The figures below illustrate the total FY10-17 Clean Water Fund allocations by watershed for (a) combined watershed-specific projects and statewide activities and technical assistance that benefit all watersheds; (b) monitoring and assessment; (c) watershed restoration/protection strategies; (d) protection/restoration implementation activities; and (e) drinking water protection.



Measure Description

This measure provides a relative sense of the amount of allocations per watershed for each of Minnesota's 81 major watersheds, as well as spending for activities that are more statewide in scope. This data is consistent with data submitted to the Minnesota Legacy website, located at http://www.legacy.leg.mn/funds/clean-water-fund.

Associated Terms and Phrases

Aquifer: Water-bearing porous soil or rock that yield significant amounts of water to wells.

Drinking water protection includes:

- *Source water protection strategies*: Wellhead protection, source water assessment, and surface water intake protection activities that protect water from streams, rivers, lakes, or aquifers that is used for drinking.
- *Water supply planning:* Activities to maintain a safe and sustainable water supply, including the development of local public water supply plans, regional water supply plans, and groundwater management area plans.

Groundwater: The water beneath the land surface that fills the spaces in rock and sediment. It is replenished by precipitation. Groundwater occurs everywhere in Minnesota and supplies about 75 percent of Minnesota's drinking water and nearly 90 percent of the water used for agricultural irrigation. Groundwater also discharges to surface water and allows streams to flow beyond rain and snowmelt periods and sustains lake levels during dry spells.

Implementation includes:

- *Restoration activities*: Implementation of best management practices, improved sewage treatment or other pollution reduction measures to bring an impaired waterbody into attainment with water quality standards. These activities are often funded in response to an approved Total Maximum Daily Load study (TMDL) that determines how much pollution needs to be reduced in order to achieve water quality standards.
- *Protection activities*: Implementation of best management practices to prevent degradation and/or improve waterbodies or aquifers currently meeting water quality standards.

Monitoring and assessment includes:

- *Condition monitoring* – Monitoring consistently throughout the open water season with the objective of assessing the ambient, or background, condition of a lake or stream reach. Results are compared against water quality standards to determine if designated uses are supported. *Load monitoring* - Flow and chemistry monitoring conducted at the mouth (or outlet) of each major watershed. Monitoring is conducted at least monthly, and more frequently during events (i.e., snowmelt or rain events). The objective of load monitoring is to capture the entire hydrograph (or variation in the amount of water flowing past a location per unit time), and to determine the pollutant load carried by a stream or river. Results are used to calculate loads, yields, and means for pollutants at the outlet of basins, watersheds, and sub-watersheds.
- *Problem investigation monitoring* – Monitoring with the objective of supporting water quality goals, often in cooperation with other interested agencies. May be conducted in response to accidental wastewater spills or discharges that may affect surface waters. Results are compared against water quality standards to determine if designated uses are supported.
- *Surface Water Assessment Grant (SWAG):* An MPCA grant that passes through funding to local partners for the purpose of conducting condition monitoring. Results are compared against water quality standards to determine if designated uses are supported.
- *Watershed Pollutant Load Monitoring Network*: An MPCA grant that passes through funding to local partners for the purpose of conducting sub-watershed load monitoring. Results are used to calculate loads, yields, and means for pollutants at the outlet of watersheds and sub-watersheds.

- *Groundwater level monitoring* – Monitoring with the objective of collecting baseline data on groundwater level fluctuations and trends in local and regional aquifers.
- *Groundwater quality monitoring* – Monitoring with the objective of collecting baseline data on groundwater chemistry fluctuations and trends in local and regional aquifers.

Partners: According to the Clean Water Legacy Act, partners are eligible regional and local government units, state agencies, political subdivisions, joint powers organizations, tribal entities, special purpose units of government, as well as the University of Minnesota and other public education institutions, according to the rules of the funding program (MN Statutes 114D.15). Partners can also include eligible nonprofit or other nongovernmental organizations, depending on the rules of the funding program.
Public Agencies: According to the Clean Water Legacy Act, public agencies means all state agencies, political subdivisions, joint powers organizations, and special purpose units of government with authority, responsibility, or expertise in protecting, restoring, or preserving the quality of surface waters, managing or planning for surface water and related lands, or financing waters-related projects. (MN Statutes 114D.15). Public agencies includes the University of Minnesota and other public education institutions.
Statewide: Spending for activities that are more statewide in scope. This includes projects with more of a statewide orientation than a watershed one, as well as technical assistance for projects provided by state agencies.

Watershed: The surrounding land area that drains into a lake, river or river system. The watershed size used for this measure is at the "major watershed" scale. There are 81 major watersheds in Minnesota.

Watershed restoration and protection strategies includes:

- *Restoration strategies*: Planning activities to restore waterbodies not meeting water quality standards ("impaired"), including the development of a Total Maximum Daily Load study (TMDL) for an impaired water. A "TMDL" means a scientific study that contains a calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are restored and maintained. It results in pollution reduction goals for all sources of a pollutant in a watershed.
- *Protection strategies*: Planning activities to protect high quality ground and surface waters that are currently achieving water quality standards.
- *One Watershed, One Plan*: Comprehensive watershed management plans developed by local governments.

Target
Not applicable

Baseline
FY 2010-11 – the first biennium of appropriations from the Clean Water Fund.

Geographical Coverage
Coverage is by watershed or statewide.

Data and Methodology

Methodology for Measure Calculation

Due to the wide variation in state agency program objectives and project management structures, each agency and even units within agencies may use different methods to calculate the dollars reported by this measure. For detailed methodology employed by each agency, contact the people listed in this report. These general guidelines were adopted by all agencies for this report to provide consistency:

Watershed-specific allocations: Best professional judgment was used to determine the distribution of spending for projects occurring in multiple watersheds or projects with unclear boundaries. In general, funding in projects benefiting multiple watersheds was divided equally among those watersheds.

Statewide and technical assistance: The amount of spending on statewide work and technical assistance is consistent with values reported to the Minnesota Legacy website. This category generally includes the total annual cost of projects with a "statewide" benefit including costs of state agency staff providing oversight and technical assistance for all statewide or watershed-specific projects; program activities; and money passed through to partners and contractors working on state-wide projects. Total cost does not include conservation easements.

See "caveats and limitations" below for more information.

Data Source

The primary data source used to develop this measure is the website "Minnesota's Legacy: Watch the Progress" at http://www.legacy.leg.mn/funds/clean-water-fund.

Details needed to allocate spending by watershed were derived from the following sources:

- BWRS's database eLINK
- DNR's project databases
- Metropolitan Council's database EIMS
- MDA's project databases
- MDH's databases for grant programs
- MPCA's databases including: MAPs/SWIFT, STORET/EQuIS, Watershed DELTA, and individual project databases
- PFA's project databases

Data Collection Period

Fiscal year 2010-2017

Data Collection Methodology and Frequency

Data should be collected annually.

It should be noted that monitoring and assessment data collection is complicated by the SWAG contract process. SWAG contracts are finalized the spring after the start of a new fiscal year, and sites monitored through SWAGs are established in STORET/EQuIS in early summer after a contract has been executed. Therefore, the earliest the watershed estimates can be made is 1.25 years after the start of a new fiscal year (i.e., can report on FY11 by the end of the first quarter of FY12). Staff salary estimates per watershed could be developed within 6 months after the start of a new fiscal year (i.e., can report on FY11 by the start of the second quarter of FY11).

Supporting Data Set

The Table 1 and Table 2 provides the data used to report on this measure.

Caveats and Limitations

Overall: The process for collecting data for this measure is a complex process and the results do not represent an exact accounting of funding allocations. Rather, the measure is intended to provide a general sense of how funds are allocated across the state using watersheds as the common geographic unit. For many projects, funding was not allocated by watershed boundaries (county, city, region, etc.) so best professional judgment was employed to determine how to assign project allocations to one or more watershed. Likewise, best professional judgment was used to determine how to allocate funding for projects that had spending in more than one activity category (i.e. monitoring and strategy development and implementation). For detailed information for funding allocations in this measure for a particular project or state agency, contact the agency representative listed below ("Measure Points of Contact").

Monitoring/assessment: Making estimates by fiscal year is difficult, as the FY divides the field season. Note that the monitoring/assessment FY estimate will actually be the cost to monitor and assess the watershed sites begun the summer of the new FY (i.e., FY 11 estimate will be the cost to monitor and assess the 2010 watershed sites). Because the monitoring and assessment work is split between MPCA staff and local partners, data is stored in many areas, and much of the data manipulation must be done manually, a large amount of work must be undertaken to break expenses down by watershed.

Future Improvements

It is anticipated that this measure will continue to evolve in future years as agencies improve their process for collecting data. Since FY 2010, there has been enhancements to the databases agencies use to collect and report out the data. Technological advances in the future will continually improve the methods in which data is stored and disseminated.

Financial Considerations

Contributing Agencies and Funding Sources

BWSR, DNR, MDA, MDH, Met Council, MPCA, PFA

Measure Points of Contact

- BWSR contact: Matt Drewitz, matt.drewitz@state.mn.us
- DNR contact: Barbara Weisman, barbara.weisman@state.mn.us
- MDA contact: Margaret Wagner, margaret.wagner@state.mn.us
- MDH contact: Tannie Eshenaur, tannie.eshenaur@state.mn.us
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- PFA contact: Jeff Freeman, jeff.freeman@state.mn.us
- Metropolitan Council contact: Lanya Ross, lanya.ross@metc.state.mn.us

Supporting Data Set – FY 2010-2017

Table 1 below show the summary and comparison of statewide and watershed funding by the four main categories of Clean Water Funds allocated to State agencies.

Table 1: FY 2010-2017 Clean Water Fund Summary Data	*Monitoring Sub-Total*	*Strategies Sub-Total*	*Implementation Sub-Total*	*Drinking Water Sub-Total*	Total
Statewide projects & technical assistance total	***$56,210,105***	***$67,578,887***	***$118,078,458***	***$33,456,575***	**$275,324,025**
Watershed projects total	***$28,709,617***	***$30,177,541***	***$162,907,726***	***$20,187,656***	***$241,982,540***

Table 2 below further breaks down the watershed project total by individual 8 digit HUC watersheds.

Table 2: FY 2010-2017 Clean Water Funds by Watershed						
Watershed Name	**HUC**	***Monitoring Sub-Total***	***Strategies Sub-Total***	***Implementation Sub-Total***	***Drinking Water Sub-Total***	**Total**
Big Fork River	09030006	*$961,989*	*$355,483*	*$73,127*	*$13,916*	*$1,404,515*
Blue Earth River	07020009	*$204,848*	*$410,934*	*$2,449,937*	*$87,240*	*$3,152,960*
Bois De Sioux River	09020101	*$711,324*	*$472,246*	*$341,338*	*$9,550*	*$1,534,458*
Buffalo River	09020106	*$161,250*	*$377,828*	*$1,392,818*	*$93,590*	*$2,025,486*
Cannon River	07040002	*$549,471*	*$442,374*	*$10,870,737*	*$1,145,919*	*$13,008,501*
Cedar River	07080201	*$14,130*	*$417,881*	*$2,976,684*	*$22,660*	*$3,431,355*
Chippewa River	07020005	*$246,816*	*$560,811*	*$2,079,953*	*$78,218*	*$2,965,798*
Clearwater River	09020305	*$342,273*	*$225,408*	*$541,731*	*$21,851*	*$1,131,263*
Cloquet River	04010202	*$220,206*	*$223,784*	*$2,040,940*	*$22,593*	*$2,507,523*
Cottonwood River	07020008	*$193,519*	*$152,327*	*$1,959,126*	*$34,286*	*$2,339,258*
Crow Wing River	07010106	*$830,282*	*$516,337*	*$845,560*	*$242,806*	*$2,434,985*
Des Moines River - Headwaters	07100001	*$122,019*	*$312,585*	*$3,701,897*	*$49,577*	*$4,186,078*
East Fork Des Moines River	07100003	*$74,198*	*$91,490*	*$206,002*	*$23,455*	*$395,144*
Kettle River	07030003	*$152,986*	*$238,634*	*$593,570*	*$10,097*	*$995,287*
Lac Qui Parle River	07020003	*$77,720*	*$521,394*	*$138,852*	*$28,503*	*$766,470*
Lake of the Woods	09030009	*$449,148*	*$989,174*	*$30,353*	*$12,200*	*$1,480,875*
Lake Superior - North	04010101	*$791,992*	*$595,379*	*$2,143,749*	*$40,188*	*$3,571,308*
Lake Superior - South	04010102	*$1,166,840*	*$819,488*	*$980,883*	*$41,722*	*$3,008,933*
Le Sueur River	07020011	*$150,241*	*$710,719*	*$1,004,161*	*$35,129*	*$1,900,250*
Leech Lake River	07010102	*$607,475*	*$280,715*	*$61,817*	*$42,165*	*$992,172*
Little Fork River	09030005	*$230,038*	*$335,767*	*$122,035*	*$15,558*	*$703,398*
Little Sioux River	10230003	*$40,320*	*$37,398*	*$194,732*	*$8,868*	*$281,318*
Long Prairie River	07010108	*$436,793*	*$265,088*	*$544,784*	*$306,551*	*$1,553,215*

Table 2: FY 2010-2017 Clean Water Funds by Watershed						
Watershed Name	**HUC**	***Monitoring Sub-Total***	***Strategies Sub-Total***	***Implementation Sub-Total***	***Drinking Water Sub-Total***	**Total**
Lower Big Sioux River	10170203	*$397,650*	*$23,746*	*$4,473,034*	*$54,664*	*$4,949,094*
Lower Des Moines River	07100002	*$29,167*	*$77,646*	*$101,278*	*$12,933*	*$221,024*
Lower Minnesota River	07020012	*$893,340*	*$403,104*	*$5,837,874*	*$1,405,514*	*$8,539,832*
Lower St. Croix River	07030005	*$981,353*	*$1,053,369*	*$10,230,403*	*$2,118,997*	*$14,384,122*
Minnesota River - Headwaters	07020001	*$308,080*	*$206,135*	*$1,283,677*	*$49,597*	*$1,847,489*
Minnesota River - Mankato	07020007	*$933,310*	*$365,118*	*$3,138,003*	*$33,024*	*$4,469,455*
Minnesota River - Yellow Medicine River	07020004	*$826,084*	*$531,210*	*$7,146,910*	*$72,962*	*$8,577,167*
Mississippi River - Brainerd	07010104	*$150,926*	*$133,343*	*$2,110,813*	*$98,591*	*$2,493,673*
Mississippi River - Grand Rapids	07010103	*$209,528*	*$337,755*	*$42,720*	*$134,279*	*$724,282*
Mississippi River - Headwaters	07010101	*$1,036,898*	*$516,484*	*$162,724*	*$77,000*	*$1,793,106*
Mississippi River - La Crescent	07040006	*$23,094*	*$191,602*	*$310,842*	*$3,697*	*$529,235*
Mississippi River - Lake Pepin	07040001	*$145,949*	*$480,366*	*$369,415*	*$774,684*	*$1,770,414*
Mississippi River - Reno	07060001	*$23,094*	*$56,832*	*$50,794*	*$49,277*	*$179,997*
Mississippi River - Sartell	07010201	*$37,268*	*$165,555*	*$1,902,313*	*$163,384*	*$2,268,520*
Mississippi River - St. Cloud	07010203	*$173,143*	*$181,816*	*$7,852,082*	*$873,059*	*$9,080,101*
Mississippi River - Twin Cities	07010206	*$1,229,374*	*$1,451,956*	*$13,350,021*	*$3,037,962*	*$19,069,313*
Mississippi River - Winona	07040003	*$688,970*	*$359,467*	*$3,647,010*	*$289,884*	*$4,985,331*
Mustinka River	09020102	*$711,324*	*$334,194*	*$475,332*	*$8,550*	*$1,529,400*
Nemadji River	04010301	*$690,932*	*$1,239,788*	*$621,521*	*$35,814*	*$2,588,055*
North Fork Crow River	07010204	*$386,924*	*$812,048*	*$4,327,630*	*$1,156,738*	*$6,683,340*
Otter Tail River	09020103	*$119,183*	*$195,691*	*$966,006*	*$629,986*	*$1,910,866*
Pine River	07010105	*$498,486*	*$212,611*	*$327,875*	*$20,138*	*$1,059,109*
Pomme de Terre River	07020002	*$86,587*	*$723,662*	*$846,218*	*$18,770*	*$1,675,237*
Rainy River - Baudette	09030008	*$36,269*	*$107,643*	*$12,442*	*$24,942*	*$181,295*

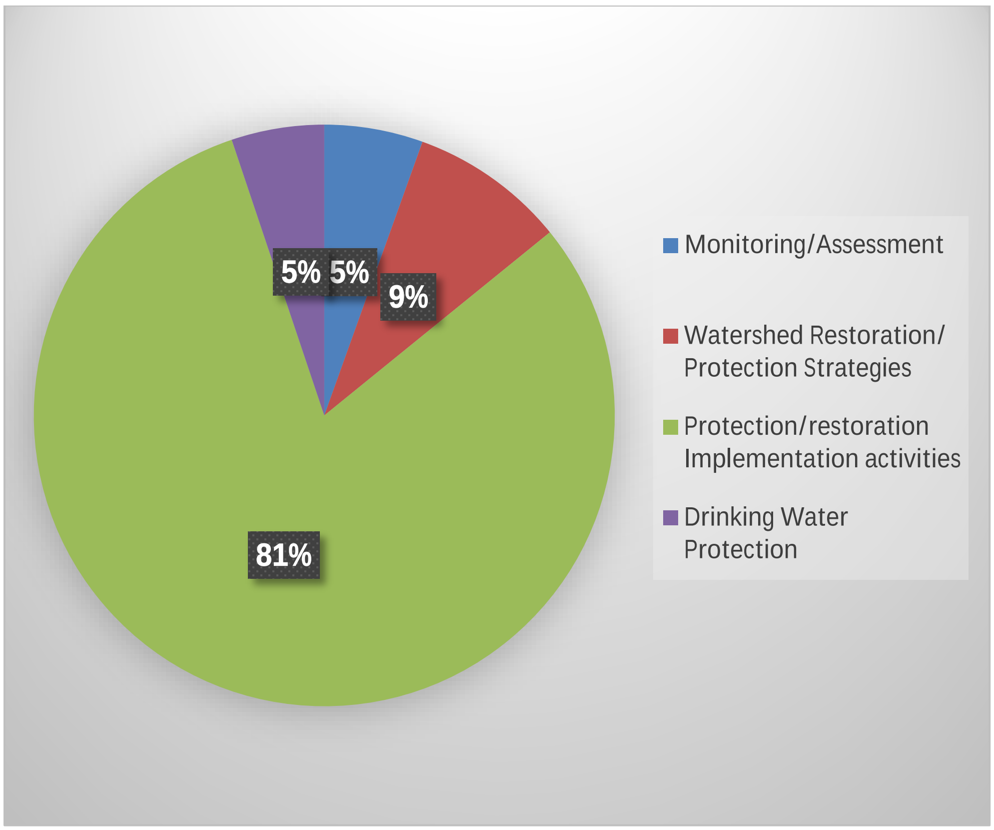
Table 2: FY 2010-2017 Clean Water Funds by Watershed						
Watershed Name	**HUC**	***Monitoring Sub-Total***	***Strategies Sub-Total***	***Implementation Sub-Total***	***Drinking Water Sub-Total***	**Total**
Rainy River – Black River	09030004	*$53,490*	*$107,643*	*$1,350,000*	*$11,176*	*$1,522,309*
Rainy River - Headwaters	09030001	*$225,542*	*$737,091*	*$3,165,580*	*$33,570*	*$4,161,783*
Rainy River - Rainy Lake	09030003	*$36,539*	*$135,592*	*$0*	*$34,959*	*$207,090*
Rapid River	09030007	*$34,838*	*$107,643*	*$0*	*$0*	*$142,481*
Red Lake River	09020303	*$469,982*	*$502,618*	*$668,800*	*$22,253*	*$1,663,654*
Red River of the North – Grand Marais Creek	09020306	*$146,299*	*$232,421*	*$853,624*	*$11,456*	*$1,243,800*
Red River of the North – Marsh River	09020107	*$63,542*	*$42,078*	*$59,058*	*$23,461*	*$188,139*
Red River of the North – Sandhill River	09020301	*$565,540*	*$295,921*	*$531,508*	*$35,328*	*$1,428,297*
Red River of the North – Tamarac River	09020311	*$166,179*	*$326,500*	*$21,334*	*$10,712*	*$524,725*
Redeye River	07010107	*$414,989*	*$184,776*	*$296,908*	*$342,324*	*$1,238,996*
Redwood River	07020006	*$188,969*	*$227,583*	*$1,048,548*	*$72,992*	*$1,538,092*
Rock River	10170204	*$140,868*	*$73,485*	*$1,363,067*	*$36,031*	*$1,613,450*
Root River	07040008	*$159,871*	*$589,922*	*$7,178,630*	*$469,860*	*$8,398,282*
Roseau River	09020314	*$70,441*	*$258,846*	*$99,702*	*$5,000*	*$433,989*
Rum River	07010207	*$614,308*	*$482,091*	*$9,869,000*	*$952,436*	*$11,917,835*
Sauk River	07010202	*$109,383*	*$318,190*	*$2,618,509*	*$844,144*	*$3,890,225*
Shell Rock River	07080202	*$0*	*$14,998*	*$142,098*	*$70,546*	*$227,642*
Snake River	07030004	*$79,278*	*$755,397*	*$3,169,490*	*$21,636*	*$4,025,802*
Snake River	09020309	*$99,631*	*$471,366*	*$119,942*	*$66,985*	*$757,924*
South Fork Crow River	07010205	*$1,404,025*	*$774,540*	*$2,804,543*	*$1,025,548*	*$6,008,656*
St. Louis River	04010201	*$1,028,312*	*$1,750,364*	*$8,802,465*	*$90,634*	*$11,671,775*
Thief River	09020304	*$473,574*	*$164,217*	*$626,710*	*$12,043*	*$1,276,544*
Two Rivers	09020312	*$455,717*	*$98,212*	*$473,262*	*$297,051*	*$1,324,242*
Upper Big Sioux River	10170202	*$368,547*	*$23,746*	*$15,873*	*$4,301*	*$412,467*
Upper Iowa River	07060002	*$23,094*	*$33,038*	*$283,401*	*$9,500*	*$349,033*
Upper Red River of the North	09020104	*$47,966*	*$249,566*	*$1,412,384*	*$80,735*	*$1,790,651*
Upper St. Croix River	07030001	*$39,557*	*$128,338*	*$17,880*	*$807,600*	*$993,375*

Table 2: FY 2010-2017 Clean Water Funds by Watershed						
Watershed Name	**HUC**	***Monitoring Sub-Total***	***Strategies Sub-Total***	***Implementation Sub-Total***	***Drinking Water Sub-Total***	**Total**
Upper Wapsipinicon River	07080102	*$5,269*	*$5,269*	*$0*	*$16,160*	*$26,698*
Upper/Lower Red Lake	09020302	*$277,589*	*$289,613*	*$50,425*	*$4,888*	*$622,515*
Vermilion River	09030002	*$0*	*$120,370*	*$10,200*	*$609,236*	*$739,806*
Watonwan River	07020010	*$623,665*	*$541,394*	*$5,103,232*	*$285,452*	*$6,553,743*
Wild Rice River	09020108	*$132,812*	*$123,204*	*$284,204*	*$34,888*	*$575,109*
Winnebago River	07080203	*$0*	*$10,000*	*$4,500*	*$1,667*	*$16,167*
Zumbro River	07040004	*$836,990*	*$487,123*	*$5,581,129*	*$312,000*	*$7,217,241*

Total dollars awarded in grants and contracts to non-state agency partners

Measure Background

Visual Depiction



Measure Description

This measure provides statewide numbers for the amount of Clean Water funding awarded to non-state agency partners on monitoring/assessment, watershed restoration and protection strategies, restoration and protection implementation activities, and drinking water protection. The data collected for this measure is consistent with the information provided to the Minnesota Legacy website: http://www.legacy.leg.mn/

Associated Terms and Phrases

Aquifer: Water-bearing porous soil or rock that yield significant amounts of water to wells.

Groundwater: The water beneath the land surface that fills the spaces in rock and sediment. It is replenished by precipitation. Groundwater occurs everywhere in Minnesota and supplies about 75 percent of Minnesota's drinking water and nearly 90 percent of the water used for agricultural irrigation. Groundwater also discharges to surface water and allows streams to flow beyond rain and snowmelt periods and sustains lake levels during dry spells.

Protection/restoration implementation includes:

- *Restoration implementation activities*: Implementation of best management practices, improved sewage treatment or other pollution reduction measures to bring an impaired waterbody into attainment with water quality standards. These activities are often funded in response to an approved Total Maximum Daily Load study (TMDL) or Watershed Restoration and Protection Strategy Document that determines how much pollution needs to be reduced in order to achieve water quality standards.
- *Protection implementation activities*: Implementation of best management practices to prevent degradation and/or improve waterbodies or aquifers currently meeting water quality standards. These activities are often funded in response to a Watershed Restoration and Protection Strategy Document

Monitoring/Assessment includes:

- *Condition monitoring* – Monitoring consistently throughout the open water season with the objective of assessing the ambient, or background, condition of a lake or stream reach. Results are compared against water quality standards to determine if designated uses are supported.
  Load monitoring - Flow and chemistry monitoring conducted at the mouth (or outlet) of each major watershed. Monitoring is conducted at least monthly, and more frequently during events (i.e., snowmelt or rain events). The objective of load monitoring is to capture the entire hydrograph (or variation in the amount of water flowing past a location per unit time), and to determine the pollutant load carried by a stream or river.
- *Problem investigation monitoring* – Monitoring with the objective of supporting water quality goals, often in cooperation with other interested agencies. May be conducted in response to accidental wastewater spills or discharges that may affect surface waters. Results are compared against water quality standards to determine if designated uses are supported.
- *Surface Water Assessment Grant (SWAG):* An MPCA grant that passes through funding to local partners for the purpose of conducting condition monitoring. Results are compared against water quality standards to determine if designated uses are supported.
- *Watershed Pollutant Load Monitoring Network* – Flow and chemistry monitoring conducted at the outlet of primarily sub-watersheds via MPCA pass through grant funding. Monitoring is conducted at least monthly, and more frequently during events (i.e., snowmelt or rain events). The objective of load monitoring is to capture the entire hydrograph (or variation in the amount of water flowing past a location per unit time), and to determine the pollutant load carried by a stream or river.

- *Groundwater level monitoring* – Monitoring with the objective of collecting baseline data on groundwater level fluctuations and trends in local and regional aquifers.
- *Groundwater quality monitoring* – Monitoring with the objective of collecting baseline data on groundwater chemistry fluctuations and trends in local and regional aquifers.

Partners: According to the Clean Water Legacy Act, partners are eligible regional and local government units, state agencies, political subdivisions, joint powers organizations, tribal entities, special purpose units of government, as well as the University of Minnesota and other public education institutions, according to the rules of the funding program (MN Statutes 114D.15). Partners can also include eligible nonprofit or other nongovernmental organizations, depending on the rules of the funding program.

Public Agencies: According to the Clean Water Legacy Act, public agencies means all state agencies, political subdivisions, joint powers organizations, and special purpose units of government with authority, responsibility, or expertise in protecting, restoring, or preserving the quality of surface waters, managing or planning for surface water and related lands, or financing waters-related projects. (MN Statutes 114D.15). Public agencies includes the University of Minnesota and other public education institutions.
Research: The collection of information about watershed or aquifer health including mapping and modeling.

Statewide projects and technical assistance: Spending for activities that are more statewide in scope. This includes projects with more of a statewide orientation than a watershed one, as well as technical assistance for projects provided by state agencies.

Watershed: The surrounding land area that drains into a lake, river or river system. The watershed size used for this measure is at the "major watershed" scale. There are 81 major watersheds in Minnesota.

Watershed restoration and protection strategies includes:

- *Restoration strategies*: Planning activities to restore waterbodies not meeting water quality standards ("impaired"), including the development of a Total Maximum Daily Load study (TMDL) for an impaired water. A "TMDL" means a scientific study that contains a calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are restored and maintained. It results in pollution reduction goals for all sources of a pollutant in a watershed.
- *Protection strategies*: Planning activities to protect high quality ground and surface waters that are currently achieving water quality standards.
- *Source water protection strategies*: Wellhead protection, source water assessment, and surface water intake protection activities that protect water from streams, rivers, lakes, or aquifers that is used for drinking.
- *Water supply planning:* Activities to maintain a safe and sustainable water supply, including the development of local public water supply plans, regional water supply plans, and Groundwater Management Area *plans.*

Implementation activities

- *Point source projects*: These are regulated wastewater and storm water via the NPDES permit.
- *Non-Point source projects*: These are best management practices or conservation practices that are addressing diffuse sources of pollution in both rural and urban areas.

- **BWSR** – Minnesota Board of Water and Soil Resources
- **DNR** – Minnesota Department of Natural Resources
- **MDA** – Minnesota Department of Agriculture
- **MDH** – Minnesota Department of Health
- **MPCA** – Minnesota Pollution Control Agency
- **PFA** - Minnesota Public Facilities Authority

Target
Not applicable

Baseline
Fiscal Year 2010-2011 – the first full biennium of appropriations from the Clean Water Fund.

Geographical Coverage
Grants and contracts to non-state agencies is presented as statewide totals per category, though much of it has been allocated to watershed-specific projects.

Data and Methodology

Methodology for Measure Calculation
Due to the wide variation in state agency program objectives and project management structures, each agency and even units within agencies may use different methods to calculate the dollars reported by this measure. For detailed methodology employed by each agency, contact the people listed in this report. The general guidelines were adopted by all agencies for this report to provide consistency.

Data Source
The primary data source used to develop this measure is the Minnesota Legacy website at http://www.legacy.leg.mn/funds/clean-water-fund.
Additional details needed to determined awards to non-state agency partners were derived from the following sources:

- BWRS's database eLINK
- DNR's project databases
- Metropolitan Council's database EIMS
- MDA's project databases
- MDH's databases for grant programs
- MPCA's databases including: MAPs/SWIFT, STORET/EQuIS, Watershed DELTA, and individual project databases
- PFA's project databases
- Met Councils' project databases

Data Collection Period
Fiscal year 2010-2017– the first four biennium's of appropriations from the Clean Water Fund.

Data Collection Methodology and Frequency
Overall: Data for this measure should be collected annually.
Monitoring: Condition monitoring and load monitoring funds are passed through to partners annually. The amounts of those contracts and the grantee/contractor's names are all captured in MAPS/SWIFT. This information is combined with other data required to be reported to the Minnesota Legislature for its web page annually. Other types of contracts with external partners are executed as needed, and are not on a set schedule.
Implementation activities: For data that is entered in eLINK, BWSR staff extracts the data by querying eLINK for BMPs implemented with Clean Water Fund dollars. Local grant recipients enter financial information into eLINK every six months, recording only those BMPs that are fully implemented at that time.

Supporting Data Set

The table below represents the combined FY 2010-2017 dollars awarded by each of the four Clean Water Fund categories.

2010-2017 Total Dollars Awarded in Grants or Contracts to Partners					
Agency	**Monitoring/ Assessment**	**Watershed Restoration/ Protection Strategies**	**Protection/restoration Implementation activities**	**Drinking Water Protection**	**Total**
BWSR	$0	$0	$169,213,771	$0	**$169,213,771**
DNR	$1,798,375	$51,040	$3,618,244	$988,630	**$6,456,289**
MDA	$1,833,140	$0	$24,160,348	$5,847,974	**$31,841,462**
MDH	$0	$0	$0	$7,743,931	**$7,743,931**
Met Council	$0	$0	$0	$4,084,592	**$4,084,592**
MPCA	$16,214,210	$31,272,503	$7,506,318	$0	**$54,993,031**
PFA	$0	$0	$87,130,365	$0	**$87,130,365**
Total	**$19,845,725**	**$31,323,543**	**$291,629,046**	**$18,665,127**	**$361,463,441**

Approximately 48 percent ($361.4M) of the total FY10-17 $742.4 million appropriation from the Clean Water Fund was awarded in grants and contracts to non-state agency partners. The balance of the remaining appropriation is largely used by state agencies to provide statewide monitoring, watershed protection and restoration strategy development, technical assistance and oversight on Clean Water Fund-supported projects.

Caveats and Limitations

Overall: The data collected for this measure do not represent an exact accounting of funding allocations to non-state agency partners but are intended to provide a general sense on the level of funding awarded and for what purpose. Best professional judgment was used to determine how to allocate funding for projects that had spending in more than one activity category (i.e. monitoring and strategy development and implementation). Due to law, some funds are allocated in phases, and thus, over time the information in this measure will change. For detailed information for funding allocations in this measure for a particular project or state agency, contact the agency representative listed below ("Measure Points of Contact").

Future Improvements

It is anticipated that this measure will continue to evolve in future years as agencies improve their process for collecting data.

Financial Considerations

Contributing Agencies and Funding Sources

BWSR, DNR, MDA, MDH, Met Council, MPCA, PFA

Measure Points of Contact

- BWSR contact: Matt Drewitz, matt.drewitz@state.mn.us
- DNR contact: Barbara Weisman, barbara.weisman@state.mn.us

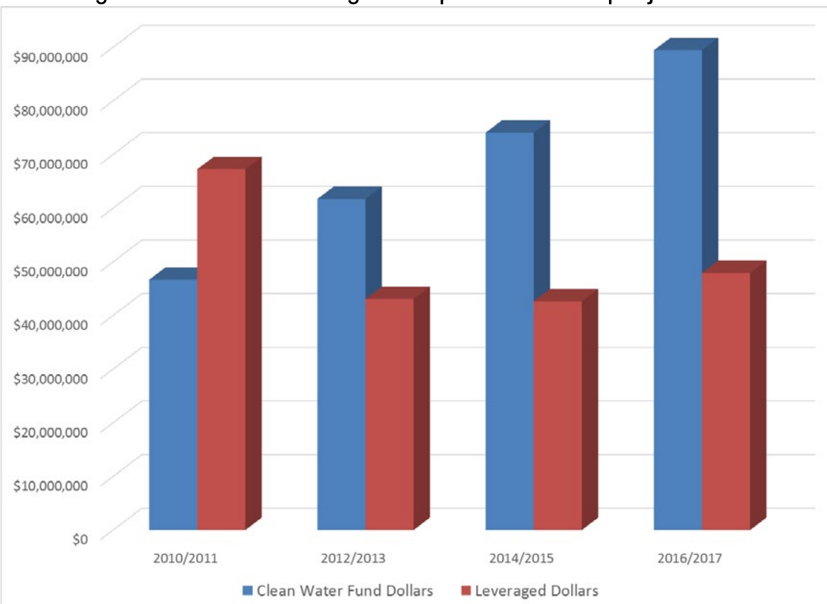
- MDA contact: Margaret Wagner, margaret.wagner@state.mn.us
- MDH contact: Tannie Eshenaur, tannie.eshenaur@state.mn.us
- MPCA contact:
    - Monitoring and assessment – Pam Anderson, pam.anderson@state.mn.us
    - Watershed restoration and strategy development – David Miller (TMDLs, CWP), david.l.miller@state.mn.us
    - Bill Dunn (wastewater/storm water), bill.dunn@state.mn.us
- PFA contact: Jeff Freeman, jeff.freeman@state.mn.us
- Metropolitan Council contact: Lanya Ross, lanya.ross@metc.state.mn.us

Amount of money leveraged by Clean Water Fund implementation activities

Measure Background

Visual Depiction

The graphics depict the annual amount of leveraged dollars calculated statewide by the various agencies receiving Clean Water funding for implementation projects.



Measure Description

This measure communicates the dollars leveraged through Clean Water Fund appropriations, from FY 2010-2017. The Clean Water appropriations comprise funding from multiple state contract, grant and loan programs as well as the Minnesota Water Quality Agriculture Certification and individual on-farm demonstration projects (Discovery Farms Minnesota and Root River Field-to-Stream Partnership). It is a direct financial measure of dollars spent on implementation activities.

Associated Terms and Phrases

To better understand this measure, it is necessary to understand the following terms and phrases:

Leveraged Funds:
For this measure, leveraged funds means the amount paid from any source other than Clean Water Funds. The amount of leveraged funds is calculated by summing all non-Clean Water funding sources contributing funding towards the project as identified at the time of award.

1. **Clean Water Funding**: For this measure, the term Clean Water Funding refers to Clean Water grants and AgBMP loans distributed through local governments for BMP implementation through special Clean Water Fund appropriations to various State grant and loan programs starting in FY10. This measure also includes dollars leveraged from on-farm demonstration projects that focus on implementing best management practices. A list of CWF programs can be found at http://www.cdf.leg.mn/.

2. **TMDL Grant Program** is designed to fund up to 50% for a maximum of $3 million for mandates resulting from an USEPA approved TMDL and Agency approved implementation plan that requires capital improvements that are beyond their current NPDES permit.
3. **Phosphorus Reduction Grant program** is designed to fund up to 75% (until June 30, 2010), and after that 50% for a maximum of $500,000 for more stringent treatment for phosphorus treatment to 1.0 mg/L or less due to a permit requirement.
4. **Point Source Implementation Grant program** is designed to fund up to 50% for a maximum of $3 million for mandates resulting in 1) Wasteload reduction to meet an EPA approved TMDL and Agency approved implementation plan that requires capital improvement that are beyond their current NPDES permit, 2) more stringent treatment for phosphorus treatment to 1.0 mg/L or less due to a permit requirement 3) Water Quality Based Effluent Limit (WQBEL, pronounced "Q-bell"), or 4) Land based discharging systems with a nitrogen limit greater than secondary standards. Starting in FY 2014, this program is replacing the TMDL and Phosphorus grant programs listed above.
5. **Ag BMP Loan Program**: This program provides low interest loans (typically 3%) with local financial institutions to farmers, agriculture supply businesses, and rural landowners. The loans are for proven pollution prevention practices that are recommended in an area's water and environmental plans. The program uses a perpetual revolving loan account structure where repayments from prior loans are continually reused to fund new loans. This program prioritizes the use of Clean Water funds to areas for implementation of practices recommended in approved TMDL Implementation Plans.
6. **Clean Water Fund Grant Program** – A grant program administered through BWSR with Clean Water Fund appropriations. More information regarding his program can be found at http://www.bwsr.state.mn.us/cleanwaterfund/index.html .
7. **Agencies Involved with this measure**
    a. **BWSR** – Minnesota Board of Water and Soil Resources
    b. **DNR** – Minnesota Department of Natural Resources
    c. **MDA** – Minnesota Department of Agriculture
    d. **MDH** – Minnesota Department of Health
    e. **MPCA** – Minnesota Pollution Control Agency
    f. **PFA** - Minnesota Public Facilities Authority
    g. **MetC**: Metropolitan Council

Target
There is no specific numeric target for this measure.

Baseline
FY 2010 serves as the baseline for this measure in which data collection began.

Geographical Coverage
Statewide

Data and Methodology

Methodology for Measure Calculation
For the purpose of this measure, any funds that are not Clean Water funds, including landowner contributions, local government unit aid, equity, and any loan, even if required as matching dollars, are included as part of the dollar amount leveraged. To calculate this measure, state agency staff collects

financial information by each program and sum these figures to provide a single count for each watershed and the state.

Data Source

Component programs of the Clean Water Fund Grants	Responsible State Agency	Funding Availability*	Data Source for Leveraged Funds
TMDL Grant Program	PFA	FY2010-FY2013	PFA spreadsheet Project applications MPCA reviewed and approved accepted as-bid
Phosphorus Reduction Grant Program	PFA	FY2010-FY2013	PFA spreadsheet Project applications MPCA reviewed and approved accepted as-bid
Point Source Implementation Grant Program (Note: this program was created when the TMDL and Phosphorus grant programs were merged and eligibility was expanded)	PFA	FY2014-FY2017	PFA spreadsheet Project applications MPCA reviewed and approved accepted as-bid
Clean Water Fund Grants	BWSR	FY2010-FY2017	eLINK
Ag BMP Loans	MDA	FY2010-FY2017	AgBMP Loan Program database
On-Farm Demonstrations (Discovery Farms, Root River Field-to- Stream Partnership)	MDA	FY10-FY2017	Project work plans and progress reports
Clean Water Partnership Grants	MPCA	FY2010-FY2015	Project work plans and progress reports
St. Louis River Direct Appropriation	MPCA	FY2010-FY2015	Project work plans and progress reports
MDH Clean Water Fund Grants (Source Water Protection Grants, Well Sealing Grants, Contaminants of Emerging Concern Education and Outreach Grants)	MDH	FY2011-2017	Project work plans and progress reports
Metropolitan Council Drinking Water Efficiency Grants	MetC	FY 2017	MetC project database

Data Collection Period

FY 2010 - FY 2017

Data Collection Methodology and Frequency

For programs administered by PFA, data collection involves reviewing accepted as-bid contract awards as compared to accepted grant award.

For programs administered by BWSR, funding cycles are on an annual basis. Local grant recipients are required to enter financial information regarding leveraged funds in eLINK, BWSR's web-based reporting and tracking tool. More information on eLINK is available at www.bwsr.state.mn.us/outreach/eLINK/manual/index.html.

The AgBMP Loan program has a revolving loan structure with regular borrower repayments. It also received periodic infusion of capital into the corpus of the program revolving pool. Data is maintained by the program in an internal database system in coordination with the state's SWIFT accounting system (data prior to July 1, 2011 is stored in MAPS accounting system). Status updates can be recalculated for any period or geographical area as needed.

- The total amount leveraged for the AG BMP Loan program equals non-state financing for loan-assisted projects. This money comes from the borrower, financing from private lenders, and other conservation financial assistance programs.
- The AgBMP loan program is supported by multiple funding sources. It is important to note that this program prioritizes the use of Clean Water funds to areas for implementation of practices recommended in approved TMDL Implementation Plans. All other funding sources, primarily federal funds, are used to finance any priority or practice identified in local comprehensive water or environmental plans.

Supporting Data Set

Clean Water Grants

Table 1. PFA Clean Water Grant Funds

Fiscal Year	PSIG Grants (including TMDL & Phosphorus)	PSIG Leveraged Funds	Small Community WWT Grants and Loans*	Small Community WWT Grants and Loans Leveraged Funds
2010	$7,524,235	$9,059,201	$131,450	$0
2011	$8,683,830	$11,739,739	$711,672	$874,414
2012	$7,782,087	$8,391,951	$81,000	$0
2013	$4,938,083	$5,057,308	$426,833	$0
2014	$7,805,174	$7,821,322	$363,678	$0
2015	$8,166,716	$7,607,004	$2,155,038	$425,000
2016	$7,810,973	$14,528,564	$2,373,718	$216,600
2017	$26,519,303	$7,623,048	$2,123,173	$1,232,123

*The small community grant and loan program is statutorily designed to provide full funding of the projects, thus there is no required local match or leverage.

Table 2. BWSR Clean Water Competitive Grant Funds

Fiscal Year	BWSR Clean Water Funds	Leveraged Dollars
2010	$11,807,597	$21,901,021
2011	$12,619,876	$15,268,561
2012	$16,874,452	$9,204,587
2013	$18,315,397	$6,683,571
2014	$21,153,418	$6,840,988
2015	$19,735,527	$6,185,756
2016	$21,703,695	$9,159,790
2017	$15,075,806	$4,465,317

* Does not included CWF Rim Easements

Table 3. MPCA Clean Water Partnership Grant Funds

Fiscal Year	MPCA Clean Water Partnership Funds	Leveraged Dollars
2010	$619,970	$1,799,510
2011	$1,314,165	$2,688,530
2012	$802,792	$442,392
2013	$790,471	$2,762,596
2014	$1,063,755	$1,070,098
2015	$1,386,206	$2,338,927

Table 4. MPCA St. Louis River Grant Funds

Fiscal Year	MPCA St. Louis River Grant Funds	Leveraged Dollars
2010/2011	$950,000	$2,692,400
2012/2013	$1,495,020	$2,903,100
2014/2015	$1,500,000	$3,144,305

Table 5. St. Croix River Association Grant Funds (implementation portion)

Fiscal Year	SCRA Grant Funds (implementation)	Leveraged Dollars
2010	$216,717	$224,416

Table 6. MDH Clean Water Fund Source Water Protection Grant Funds

Fiscal Year	MDH Clean Water Source Water Protection Funding	Leveraged Dollars
2011	$374,895	$608,835
2012/2013	$2,383,655	$1,031,814
2014/2015	$3,167,162	$1,900,885
2016/2017	$1,854,654	$2,246,749

Table 7. MDA Clean Water Fund supported AgBMP Loans

Fiscal Year	Total MDA AgBMP Loan Amount	Leveraged Funds
2010	$241,961.70	$338,650.00
2011	$1,169,955.49	$418,970.10
2012	$2,923,892.75	$2,529,312.14
2013	$2,752,814.39	$3,261,890.38
2014	$1,986,726.16	$835,789.56
2015	$1,919,422.26	$482,197.20
2016	$2,242,160.39	$542,894.68
2017	$3,155,823.94	$475,304.18

Table 8. MDA On-farm Demonstration Projects

Fiscal Years	Name of Project	Clean Water Fund Investment	Leveraged Dollars
2010/2011	Discovery Farms Minnesota	$250,000	$549,636
2012/2013	Discovery Farms Minnesota	$ 388,838	$ 648,507
2014/2015	Discovery Farms Minnesota	$393,776	$884,670
2016/2017	Discovery Farms Minnesota	$387,072	$812,934
2010/2011	Root River Field-to-Stream Partnership	$395,000	$125,000
2012/2013	Root River Field-to-Stream Partnership	$222,992	$0
2014/2015	Root River Field-to-Stream Partnership	$224,394	$19,500
2016/2017	Root River Field-to-Stream Partnership	$478,000	$33,000
2010-2013	Rosholt Farm	$ 23,882	$175,000
2013	Minnesota Agricultural Water Quality Certification Program	$1,500,000	$50,000
2014/2015	Minnesota Agricultural Water Quality Certification Program	$3,000,000	$3,002,512
2016/2017	Minnesota Agricultural Water Quality Certification Program	$5,000,000	$3,880,000
2013-2016	Conservation Innovation Grant Edge of Field Monitoring	$89,937	$100,402
2016/2017	Red River Valley Drainage Water Management	$274,398	$79,676

Table 9: Metropolitan Council Drinking Water Efficiency Grants

Fiscal Year	Metropolitan Council Drinking Water Efficiency Grants	Leverage
2017	$500,000	$198,281

Table 10. Cumulative Clean Water Funding and Leveraged Dollars from all State Agencies

Table 10 below contains the source data for the graphic on the first page of the metadata report for this measure.

Fiscal Year	Clean Water Fund Dollars	Leveraged Dollars
2010	$21,351,372	$35,068,816
2011	$25,683,834	$33,345,067
2012	$30,709,476	$22,884,953
2013	$31,001,772	$20,155,508
2014	$36,542,786	$21,078,645
2015	$37,532,944	$21,549,331
2016	$38,129,886	$27,981,977
2017	$51,371,168	$17,520,253

Caveats and Limitations

For PFA, the above estimates account for only TMDL or Phosphorus eligible costs. Often other facility improvements are also pursued at the same time to utilize economies of scale and other fixed costs such as equipment mobilization.

For most Clean Water Fund programs, BWSR requires a 25% match requirement for all grant dollars. BWSR also has a $30,000 grant minimum as well.

In FY11, up to $300K from AgBMP loan program may be used for administrative purposes; any amount not used for that purpose by the end of the fiscal year will be added to the program's revolving loan funds.

For the 2018 report, past data was reconciled with updated database information from each respective agency to ensure reporting accuracy.

Future Improvements

Nothing identified at this time

Communication Strategy

Target Audience

Stakeholders with interest in this measure include the State legislature, the Clean Water Council, and state agency partners.

Associated Messages

This measure depicts how much non-state funds the Clean Water Fund is leveraging and is a direct measure of dollars being spent of implementation.

Measure Points of Contact

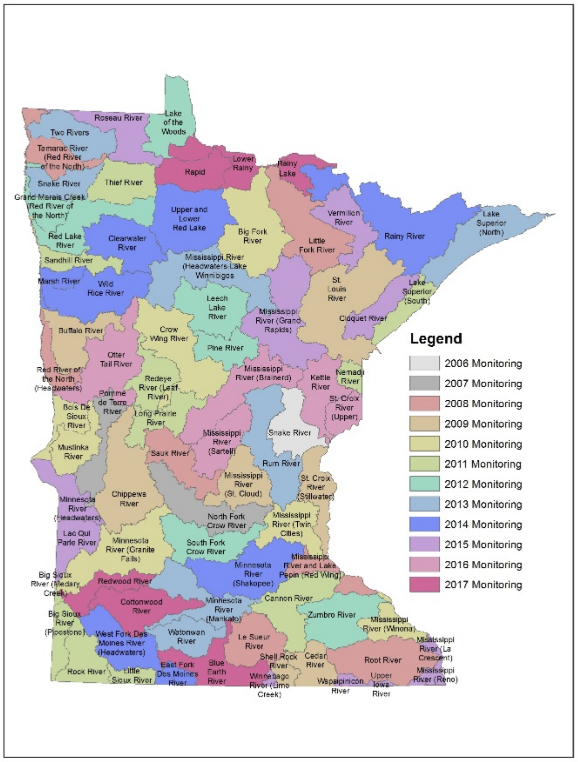
- BWSR contact: Matt Drewitz, matt.drewitz@state.mn.us
- DNR contact: Barbara Weisman, barbara.weisman@state.mn.us
- MDA contact: Margaret Wagner, margaret.wagner@state.mn.us

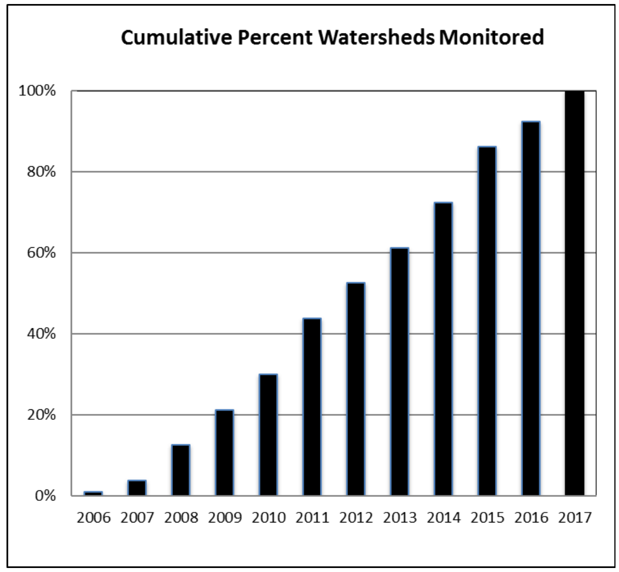
- MDH contact: Tannie Eshenaur, tannie.eshenaur@state.mn.us
- MPCA contacts:
  - David Miller (Clean Water Partnership), david.l.miller@state.mn.us
  - Bill Dunn (wastewater/storm water), bill.dunn@state.mn.us
- PFA contact: Jeff Freeman, jeff.freeman@state.mn.us
- Metropolitan Council contact: Lanya Ross, lanya.ross@metc.state.mn.us

Percent of State's Major Watersheds Intensively Monitored through the Watershed Approach

Measure Background

Visual Depiction





Measure Description

Percent of the state's major watersheds that have been intensively monitored for background condition for water chemistry and biology through the MPCA's intensive watershed monitoring approach.

Associated Terms and Phrases

Condition monitoring: Monitoring the background, or ambient, condition of a lake or stream reach. This type of monitoring typically requires monitoring once or twice per month during the open water season for a minimum of two years. The resulting data are compared to state and federal water quality standards put in place to support various uses (drinking water, aquatic recreation, aquatic life, consumption, etc.) to determine if the resource is exceeding standards (i.e., is "impaired") and in need of restoration or is meeting standards and in need of protection.

Intensive watershed monitoring (IWM): A ten-year rotational cycle wherein an average of 8 of Minnesota's 80 major (8-digit hydrologic unit code) watersheds are intensively monitored each year. During intensive watershed monitoring, additional focus is placed on monitoring the outlets of subwatersheds (aggregated 12 -digit hydrologic unit code) for biota (fish and invertebrates) and physical habitat, and to sample for chemical parameters ten times. One-time biological, physical and chemical sampling is also conducted at the outlet of the 14 -digit hydrologic unit code watersheds. During intensive watershed monitoring, all lakes $\geq$500 acres and at least 25% of lakes 100-499 acres are

monitored for physical and chemical parameters. Biological monitoring on lakes is conducted by the Department of Natural Resources and assessments for aquatic life use based on a Fish index of biotic integrity began in 2015 (2013 IWM start year watersheds)
Major watershed: 8-digit hydrologic unit code (HUC) watersheds in Minnesota; there are 81 in Minnesota.

Target

Intensively monitor ~10 percent of the state's major watersheds per year; 100% through 2018 (end of the first cycle).

Baseline

The first watershed was intensively monitored for stream biology in 2006 as a pilot project. Two additional watersheds were intensively monitored for stream biology in 2007, but 2008 marks the year the state was fully ramped up for the full IWM monitoring effort. The last watersheds of the first 10-year intensive monitoring cycle will begin monitoring in 2018.

Geographical Coverage

Statewide.

Data and Methodology

Methodology for Measure Calculation

The number, cumulative percent and the identity of watersheds that have been intensively monitored is kept in a spreadsheet (OPM1_watersheds intensively monitored.xls) that automatically updates the bar graph. The spreadsheet is found in this folder on the MPCA's server: X:\Agency_Files\Water\Condition Monitoring\Measures\Lakes & Streams\OPM1_Watersheds intensively monitored. The map is generated using the iwm_monitor_years.lyr on the MPCA's server: R:\mpca\iwm_monitor_years.lyr.

Data Source

MPCA spreadsheet tracks the IWM schedule. The number, cumulative percent and the identity of watersheds that have been intensively monitored is kept in a spreadsheet (OPM1_watersheds intensively monitored.xls).

Data Collection Period

2006-2018 for the first IWM cycle.

Data Collection Frequency

Updated annually (each January) based on new watershed monitoring starts; a schedule has been developed for the full 10 years and is updated annually.

Supporting Data Set

IWM year	# watersheds intensively monitored	Cumulative % completed	Names of watersheds
2006	1	1%	Snake River
2007	2	4%	Pomme de Terre, North Fork Crow River
2008	7	12%	Tamarac R, Upper Red R, Root R, Le Sueur, Little Fork, Mississippi R (Lake Pepin)

2009	7	21%	Buffalo R, Chippewa R, St. Louis R, Lower St. Croix R, Cedar R, Shell Rock R, Mississippi R (St. Cloud)
2010	7	30%	Big Fork R, Crow Wing R, Minnesota R (Yellow Medicine R), Mississippi R (Winona), Bois de Sioux R, Mustinka R, Mississippi R (Twin Cities)
2011	11	43%	Lake Superior (South), Nemadji River, Redeye River, Long Prairie River, Cannon River, Red River of the North – Sandhill River, Thief River, Upper Big Sioux River, Lower Big Sioux River, Rock River, Little Sioux River
2012	7	52%	Leech Lake River, Pine River, South Fork Crow River, Zumbro River, Red Lake River, Red River – Grand Marais Creek, Lake of the Woods
2013	7	60%	Two Rivers, Snake River, Lake Superior (N), Rum River, Mississippi River (Headwaters), Minnesota River (Mankato), Watonwan River
2014	9	73%	Red River of the North - Marsh River, Wild Rice, Clearwater, Upper/Lower Red, Rainy, Lower MN, Des Moines, Lower Des Moines, EF Des Moines
2015	11	86%	Roseau, Vermilion, Cloquet, MN Headwaters, LQP, Miss GR, Upper Wapsipinicon, Upper IA, Miss Reno, Miss La Crescent, Winnebago
2016	5	92%	Miss Brainerd, Miss Sartell, Otter Tail, Upper St Croix, Kettle
2017	6	100%	Redwood, Cottonwood, Blue Earth, Rainy Lower, Rapid, Rainy Lake

Caveats and Limitations

It takes two years to complete the IWM monitoring, so this measure tracks start dates only; assessment follows after the second year of intensive monitoring. This won't always show a steady 10% of watersheds per year since the size of watersheds (and their associated number of sites) will vary from year to year. The 10-year schedule requires us to start between 6 and 8 watersheds each year to stay on track.

Future Improvements

NA

Financial Considerations

Contributing Agencies and Funding Sources

Funding for monitoring that supports the MPCA's Intensive Watershed Monitoring design comes from the Minnesota Clean Water Fund.

Communication Strategy

Target Audience

Local, state and federal agencies and the general public.

Associated Messages

This measure conveys our progress in meeting our statewide monitoring responsibilities. Since restoration and protection planning work follows condition monitoring and assessment, this measure also conveys to other MPCA staff and local partners when restoration and protection planning may begin in their regions.

Outreach Format

TBD.

Other Measure Connections

The "rate of impairment/unimpairment of surface water statewide and by watershed" measure reports findings from condition monitoring data that has been assessed, including the percentage of lakes and streams that are meeting or exceeding water quality standards statewide and by watershed.

Measure Points of Contact

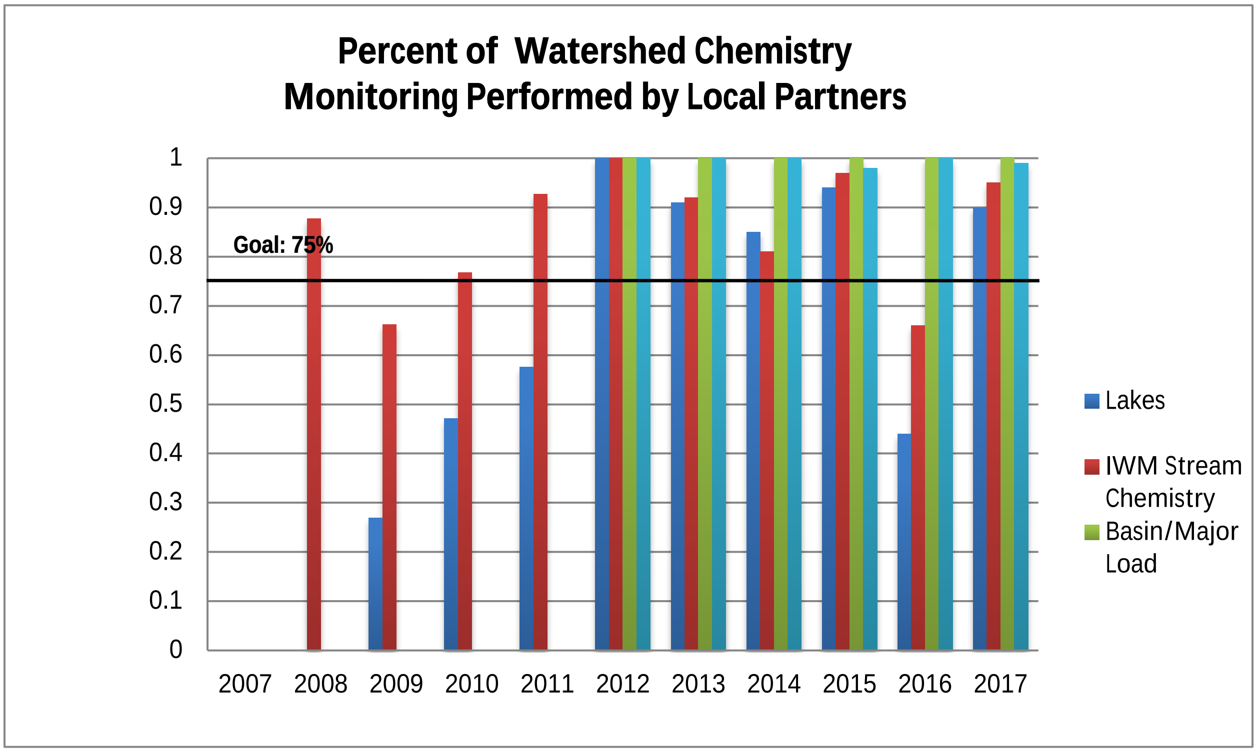
Agency Information

Pam Anderson, MPCA, Water Quality Monitoring Unit supervisor, pam.anderson@state.mn.us

Percent of intensive watershed chemistry monitoring performed by local partners

Measure Background

Visual Depiction



Measure Description

This measure tracks the percentage of intensive lake and stream chemistry monitoring that is performed by local partners. 2007-2012 reporting shows only lake and stream condition monitoring conducted by local partners. Reporting local monitoring of basin, major and intermediate load monitoring sites began in 2012.

Associated Terms and Phrases

Condition monitoring: Monitoring the background, or ambient, condition of a lake or stream reach. This type of monitoring typically requires monitoring once or twice per month during the open water season for a minimum of two years.

Intensive watershed monitoring: A ten-year rotational cycle wherein an average of 8 of Minnesota's 80 major (8-digit hydrologic unit code) watersheds are intensively monitored each year. The outlet of each major watershed is monitored for physical and chemical parameters monthly on a continual basis for baseflow and more frequently during "events", such as snowmelt and storms (termed 'load monitoring'). During intensive watershed monitoring, additional focus is placed on monitoring the outlets of subwatersheds (aggregated 12 -digit hydrologic unit code) for biota (fish and invertebrates) and physical habitat, and to sample for chemical parameters ten times. One-time biological, physical and chemical sampling is also conducted at the outlet of the 14 -digit hydrologic unit code watersheds.

During intensive watershed monitoring, all accessible lakes $\geq$500 acres and at least 25% of lakes 100-499 acres are monitored for physical and chemical parameters. Indices of biological integrity are now used based on Fish for aquatic life use assessments in lakes; IWM start year 2013 watersheds were the first to have it implemented.

Intermediate load monitoring: Flow and chemistry monitoring conducted at the mouth (or outlet) of some 12-digit watersheds (12-digit or smaller hydrologic unit code scale). Monitoring is conducted at least monthly, and then more frequently during events (i.e., snowmelt or rain events). The objective of load monitoring, in general, is to capture the entire hydrograph, and to determine the pollutant load carried by a stream or river. Intermediate watershed load monitoring data are critical for developing watershed restoration plans by providing finer scale data to calibrate numerical watershed flow models, to inform "stressor identification" efforts, and to better define areas of concern.

Load monitoring: Flow and chemistry monitoring conducted at the mouth (or outlet) of each major (8-digit hydrologic unit code scale) watershed. Monitoring is conducted at least monthly, and then more frequently during events (i.e., snowmelt or rain events). As with the intermediate load monitoring, the objective is to capture the entire hydrograph, and to determine the pollutant load carried by a stream or river. Watershed loads are also used to assess trends in the stream water quality of a watershed over time, and to see how data from a given year compare to the long-term record for a watershed. Sites are located at the outlet of 8-digit hydrologic unit code watersheds and at the outlet of 4-digit hydrologic unit code basin watersheds.

Local partners: Includes soil and water conservation districts, watershed districts, watershed management organizations, local units of government (i.e., counties, cities, townships, lake associations, and lake improvement districts), regional governmental groups, Minnesota colleges and universities, nonprofit organizations, and American Indian Tribal governments in Minnesota.

Major watershed: 8-digit hydrologic unit code (HUC) watersheds in Minnesota; there are 80 in Minnesota.

Surface Water Assessment Grants (SWAG): Clean Water Fund pass-through professional/technical contracts from MPCA to local partners for condition monitoring, including intensive watershed monitoring, activities.

Watershed Pollutant Load Monitoring Network Grants (WPLMN): Clean Water Fund pass-through funds (joint powers agreements, professional/technical contracts) from MPCA to local partners for intermediate, major watershed, and basin load monitoring activities.

Target

An annual goal of 75% participation has been set.

Baseline

The baseline year is 2007, which is the first year that the MPCA encouraged local partners to help conduct monitoring in support of the intensive watershed approach. Lakes and load monitoring were first brought into the intensive watershed monitoring design in 2009. Intermediate load monitoring (WPLMN) was brought into this design starting in 2012.

Geographical Coverage

Watershed (major watershed scale)

Data and Methodology

Methodology for Measure Calculation

The MPCA tracks the list of watershed stream sites and lakes offered annually and those that were picked up by local partners (Master Lakes_10X_EBS site spreadsheet.xlsx). For streams, the percentage monitored by partners is calculated by dividing the total number of stream sites the MPCA chosen to represent the major watershed by the number of those sites being sampled by local partners. For lakes, the total number of priority lakes (those less than 500 acres that have not yet been monitored or assessed) is divided by the total number of those monitored by local groups. The percentage of sites monitored by local partners is updated each January on a spreadsheet (PL2_Watershed sites monitored by locals.xls) that automatically updates the bar graph. Both the Priority sites and PL2_Watershed sites monitored by locals spreadsheet are found in this folder on the MPCA's server: X:\Agency_Files\Water\Condition Monitoring\Measures\Lakes & Streams\PL2_Watershed sites monitored by locals.

Data Source

Spreadsheets tracked by MPCA Water Quality Monitoring Unit supervisor and the SWAG and WPLMN Grant Coordinators.

Data Collection Period

The first IWM cycle will span from 2006-2018. This measure is updated annually when IWM monitoring by the local partner first begins.

Data Collection Frequency

Updated annually (each January), after the SWAG grants have been awarded.

Supporting Data Set

IWM year	IWM lakes	IWM 10X stream sites	Basin/Major Load sites	Intermediate load sites
2007		0%		
2008		88% (50/57 sites)		
2009	27% (62/230 lakes)	67% (53/79 sites)		
2010	47% (66/140 lakes)	76% (53/70 sites)		
2011	58% (42/73 lakes)	93% (64/69 sites)		
2012	100% (34/34 lakes)	100% (62/62 sites)	100% (54/54 sites)	100% (3/3 sites)
2013	91% (52/57 lakes)	92% (77/84 sites)	100% (45/45 sites)	100% (3/3 sites)
2014	85%	81%	100%	100%
2015	94%	97%	100%	98%
2016	44%	66%	100%	100%
2017	90%	95%	100%	99%

Recruitment for local monitoring of lakes and major load sites within the watershed approach began in 2009. Intermediate load monitoring began in 2012.

Caveats and Limitations

This measure only considers lakes and stream sites that have been offered to local partners through professional/technical contracts. There are types of lake and stream monitoring that are specialized and are not routinely offered to external partners, and sites that fall into these specialized categories and are held for monitoring by MPCA staff are not counted in the measure totals. For instance, the 92% figure cited for 2013 IWM streams reflects the fact that 77 of the 84 stream sites offered to local partners in the Surface Water Assessment Grant RFP were picked up by local partners.

The variability surrounding how much of the intensive watershed monitoring is conducted by locals is largely due to capacity. Some local partners are simply not able to take on additional work, even when funding is offered. We strive to improve our communication with local partners to ensure that they are aware that monitoring opportunities exist and to seek ways to ease any burden to them; however, there may always be cases where the mix of watersheds in a given year is one in which we have little local capacity.

MPCA's Water Monitoring Strategy indicates that agency monitoring will occur on the largest lakes and a percentage of smaller lakes. MPCA staff will choose a subset of the lakes annually for monitoring by agency staff, and provide lakes, above and beyond the capacity of the agency to local partners for completion.

Note: This measure only captures local efforts towards condition monitoring needed to assess resources for use support. It does not capture local efforts towards restoration/protection plan development, investigative monitoring, or implementation activities.

Future Improvements

N/A

Financial Considerations

Contributing Agencies and Funding Sources

Funding for monitoring that supports the MPCA's Intensive Watershed Monitoring design comes from the Minnesota Clean Water Fund.

Communication Strategy

Target Audience

Local, state and federal agencies and the general public.

Associated Messages

This message conveys the extent to which local partners are involved in MPCA lake and stream chemistry condition monitoring.

Outreach Format

TBD

Other Measure Connections

This measure could be connected to "percent of major watersheds that have been intensively monitored" because these efforts of local partners in this measure are a large component of our overall condition monitoring effort.

Measure Points of Contact

Agency Information

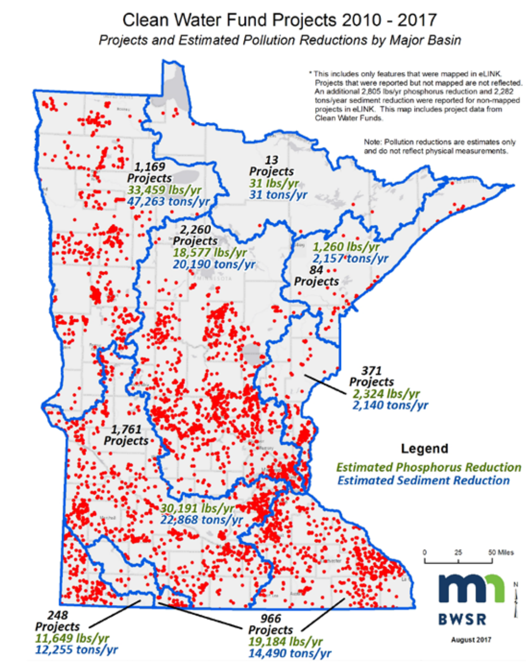
Pam Anderson, MPCA, Water Quality Monitoring Unit supervisor, pam.anderson@state.mn.us.

Number of nonpoint source best management practices implemented with Clean Water funding and estimated pollutant load reductions

Measure Background

Visual Depiction

Graphics should depict number of best management practices (BMPs) implemented statewide, annually and then cumulatively over the 25 year period of the Clean Water Fund.



IPs implemented with Clean Water funds and the estimated associated reduction in sediment and phosphorus reaching surface waters. It does not reflect BMPs implemented through other programs aimed at accelerating BMP adoption. This measure is strictly concerned with Clean Water funded implementation programs.

It is an indirect or surrogate measure of environmental response. It does not provide information on watershed health, but does provide information on efforts to reduce pollutant loads over time that are likely to improve watershed health.

Associated Terms and Phrases

To better understand this measure, it is necessary to understand the following terms and phrases. Definitions used in this measure are as follows:

BMPs: Conservation practices that improve or protect water quality in agricultural, forested, and urban areas.

Clean Water Funding: For this measure, the term Clean Water Funding refers to Clean Water Grants distributed to local governments for BMP implementation through special Clean Water Fund appropriations to various State grant programs. Clean Water funding also refers to AgBMP loans issued

to local governments for the implementation of any practice that protects or restores water quality. A list of CWF grant and loans programs can be found at http://www.legacy.leg.mn/.
Phosphorus: In this measure, we report the estimated reduction in the amount of total phosphorus reaching surface waters as a result of runoff or soil erosion (sheet, rill, gully erosion, or steam channel).
Sediment Loss: The estimated amount of sediment reaching the nearest surface water body as a result of soil erosion from water (sheet, rill, gully erosion, or stream channel).

Target
There is no specific numeric target for this measure to date.

Baseline
FY 2010 serves as the baseline for this measure.

Geographical Coverage
Statewide and by watershed

Data and Methodology

Methodology for Measure Calculation
The Clean Water Fund comprises funding from multiple state grant and loan programs. To calculate this measure, state agencies first collect data on the number of BMPs implemented with Clean Water Funds by each program and then sum these figures to provide a single count for each watershed and for the state.
Pollutant estimates are entered into the Minnesota Board of Water and Soil Resources' (BWSR's) web-based grant reporting and tracking tool, eLINK, by grant recipients when entering BMP data. The State of Minnesota does not require a specific methodology for developing pollutant load estimates. Pollutant load reductions using existing models developed for estimating pollutant load are acceptable. BWSR provides pollutant estimators for eLINK based on soil erosion (sheet, rill, and gully and stream channel). Sediment reduction estimates in eLINK are based on the distance to the nearest surface waters and soil loss calculations using USDA's Revised Universal Soil Loss Equation (RUSLE2). Phosphorus reduction estimates are derived from sediment reduction estimates. Detailed information on the calculations used in eLINK for estimating pollutant load reductions is available from at: http://www.bwsr.state.mn.us/outreach/eLINK/manual/index.html.
Estimates of pollutant load reductions for AgBMP loans are based on tabled values reported in scientific literature. Values are determined using empirical data; however they are averages and are not site-specific. The MDA continues to gather information about the effectiveness of agricultural BMPs and support research projects that provide more comprehensive empirical data on practices that the loan program supports.
Estimating the environmental benefit of specific management practices can be done numerous ways. The most common are to develop computer models, use values in from the scientific literature, or base estimates on the best professional judgment of experts. Regardless of the method used, some uncertainty remains in every estimate. State agencies continue to improve and refine estimates, enabling them to better quantify the environmental benefits of conservation practices.

Data Source
The table below shows the source of the BMP data for each of the Competitive Clean Water Grants component programs.

Clean Water Fund programs	Responsible Agency	Funding availability by fiscal year*	Database
Competitive Clean Water Fund Grants	BWSR	10,11,12,13,14,15, 16, 17	eLINK
Clean Water Fund Ag BMP Loans (CWF is one of five funding sources that support this loan program, CWF supported loans must be issued in areas with completed TMDL plans)	MDA	10,11,12,13, 14,15, 16, 17	AgBMP Loan Program database

For programs administered by BWSR, local grant recipients are required to enter BMP data in eLINK. More information on eLINK is available at www.bwsr.state.mn.us/outreach/eLINK/manual/index.html. Data was also provide by the BWSR easement program on the number of easements processed from 2010-2017. Note, in the 2016 CWF Performance Report, a typographical error was found that erroneously reported 4,790 easements being processed, but the actual number was 479 easements. This problem was reconciled and corrected for the 2018 report (490 easements covering 7,279 acres). The MDA also provided an update on progress made on the Minnesota Agricultural Water Quality Certification Program, which has now certified 283,000 acres on 483 farms with an addition of 875 new conservation practices implemented.

Data Collection Period

The data collection period is FY10 through FY17 for Clean Water Grants and for AgBMP loans. As explained below in Caveats and Limitations, there is a lag time between grants being awarded and BMPs being fully implemented and recorded. The dataset will be complete once all of the BMPs funded with FY 2010-2017 are fully implemented and recorded. Until then, the dataset for this measure only provides a snapshot in time. Data collection will continue for the duration of the Clean Water Fund (until 2034).

Data Collection Methodology and Frequency

Data on the number of and type of BMPs implemented with Clean Water Funds are extracted from various databases established by state agencies to track Clean Water Grants programs (see Data Source above). The data collection methods and frequency vary by program. The programs and respective databases existed well before Clean Water Funds became available and therefore were not designed specifically with Clean Water Fund tracking in mind.

For data that is entered in eLINK, BWSR staff extracts the data by querying eLINK for BMPs implemented with Clean Water Fund dollars. Local grant recipients enter BMP information into eLINK every six months, recording only those BMPs that are fully implemented at that time. BMP data is analyzed by the fiscal year the grant was awarded rather than the calendar year the BMP was installed.
AgBMP loan information is stored in MDA's AgBMP loan database. It is updated whenever new loans are issues. Reports can be generated at any time and for any geographic region.

Supporting Data Set

Below are data sets from each of the state agencies participating in data collection for this measure (see Data Source above).

Cumulative Non-Point Source BMPs funded by Clean Water Fund (BWSR Funded Practices)

Major Basin	Number of BMPs	Sediment tons/year	Phosphorus lbs/year

Red River	1,169	47,263	33,459
Rainey River	13	31	31
Upper Miss	2,260	20,190	18,577
Lake Superior	84	2,157	1,260
St. Croix	371	2,140	2,324
Minnesota	1,761	22,868	30,191
Lower Miss	966	14,490	19,184
Missouri	248	12,255	11,649
Totals	**6,872**	**121,394**	**116,675**

Caveats and Limitations

- This measure only tracks BMPs implemented with funding from Clean Water Fund Grants and Loans.
- Clean Water Fund Grants are for three years, resulting in a lag time between when funds are awarded and when BMPs are fully implemented and recorded in eLINK. This measure reports only BMPs that are fully implemented; it does not report on those that are planned or in progress.
- Pollution reductions entered into eLINK are calculated at the field scale, not the watershed scale.
- BMPs vs. Projects: The Minnesota Department of Agriculture's AgBMP Loan Program database does not record BMPs implemented per se, but rather loan projects completed. Most loan projects involve a single BMP or cluster of related BMPs. For example, a loan might finance an entire feedlot runoff control system or just one component. The same is true for most other conservation financial assistance programs. A BMP crosswalk is being developed to facilitate multi-program tracking.
- Potential Double-Counting of BMPs: An individual BMP may be co-funded by several Clean Water Fund implementation programs. For example, a gully/grade stabilization structure might be funded 75% through a BWSR grant and 25% by an AgBMP loan—with both programs counting the same structure in their respective databases. In another example, a BWSR grant might provide financial incentives for a farmer to switch to no-till, while an AgBMP loan finances the farmers' purchase of a no-till drill —again, both programs might record the same structure. Until a method is developed to identify such projects and coordinate the way they are recorded, it is necessary to report eLINK-entered data and AgBMP Loan data as separate figures or, if totaled, it should be noted that data might overlap and result in double-counted BMPs.
- Incomplete Data on Pollutant Load Reductions: Currently, pollutant load reductions can be calculated only for BMPs recorded in eLINK. As noted under Data Source above, not all Clean Water funded BMPs are recorded in eLINK at this time; some are recorded only in other program-specific databases.

Future Improvements

Improvements to this measure will be made over time. The type of pollutant reductions estimated in eLINK will expand in the short-term; therefore, this measure will track additional estimated pollutant load reductions associated with BMPs implemented with Clean Water funding.

Ideally this measure will be able to compare estimated pollutant load reductions in a particular watershed with pollutant load reduction targets established through TMDLs and other plans. However, accurate comparisons would require tracking all BMPs in a watershed, not just those implemented using Clean Water funding, as well as point source pollutant load reductions.

Eventually the tracking of BMPs in this measure may be replaced by measures of targeted implementation.

Financial Considerations

Contributing Agencies and Funding Sources

This measure only tracks BMPs funded with Clean Water funding, although eLINK tracks a larger universe of BMPs funded through a wide array of funding sources.

Communication Strategy

Target Audience

Stakeholders with interest in this measure include the State legislature, the Clean Water Council, and state agency partners.

Associated Messages

This primary message associated with this measure is to demonstrate the amount of implementation occurring as a result of available funds. In addition, this measure provides information on expected pollutant load reductions associated with implementation. Therefore, a secondary message is that pollutant load reductions in the short-term will help to create water quality improvements in the long-term.

Other Measure Connections

This measure doesn't explicitly link to other measures, but will help to provide an understanding of trends in key water quality and quantity parameters for lakes, streams, and groundwater measure.

Measure Points of Contact

Agency Information

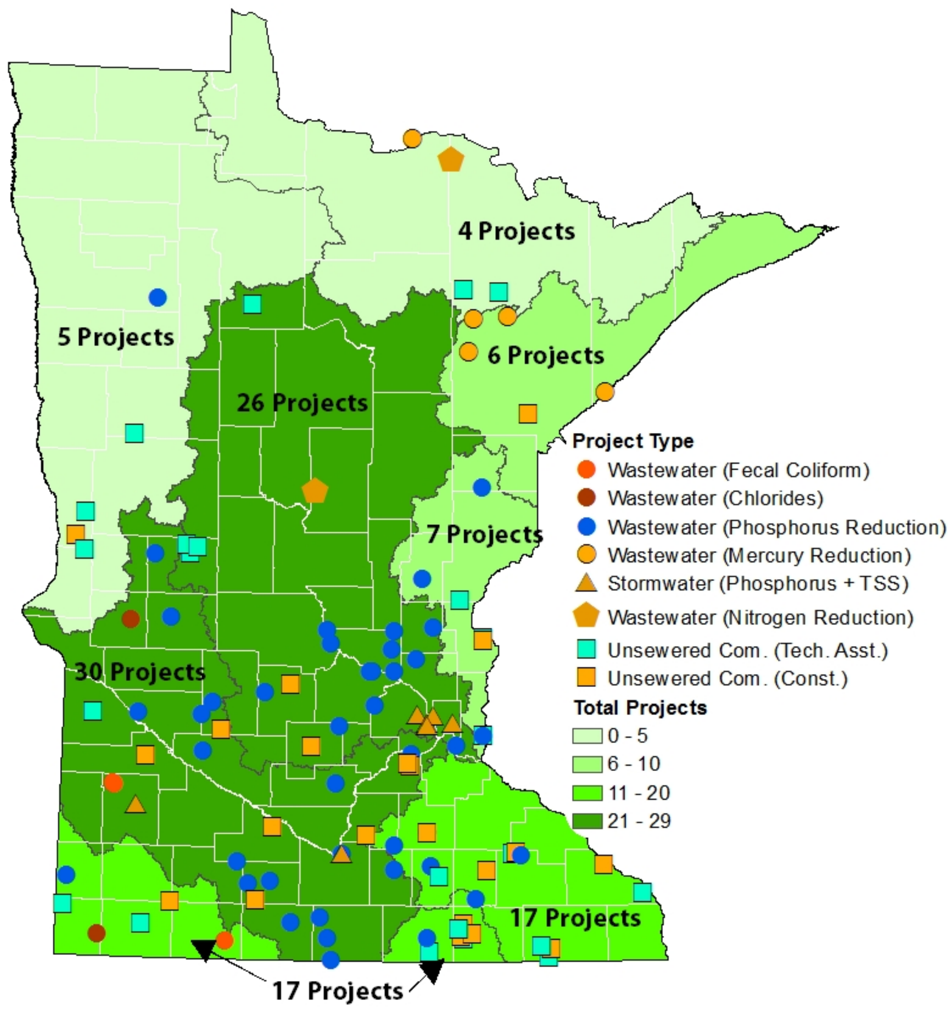
Matt Drewitz, Minnesota Board of Water and Soil Resources (BWSR): matt.drewitz@state.mn.us
Aaron Spence, MNIT@BWSR: aaron.spence@state.mn.us
Conor Donnelly, MNIT@BWSR: conor.donnelly@state.mn.us
Dwight Wilcox, Minnesota Department of Agriculture, dwight.wilcox@state.mn.us

Number of municipal point source construction projects implemented with Clean Water Funding and estimated pollutant load reductions

Measure Background

Visual Depiction

Municipal Infrastructure Project by Major Basin, 2010-2017



Measure Description

This measure is designed to document and track outcomes on the wastewater and stormwater point source construction projects initiated with Clean Water Funds and the estimated reduction in pollutant loadings reaching surface waters.

The focus of this measure is focused on phosphorus, mercury in wastewater projects, total suspended solids in stormwater projects and non-compliant sub-surface sewage treatment system as it provides

the easiest means to compare progress across the broad range of pollutants affected by TMDL's waste load allocations. It does not provide information or contextual outcomes on other federal and state funded projects and their resulting environmental progress.
These projects are a result of increased treatment requirements resulting from a TMDL waste load allocation, statewide permit requirements or water quality based effluent limits (WQBEL or "Q-bell" are pre-TMDL discharge limits that wastewater facilities must meet in order not to contribute or create an impairment). As a result of these capital investment and resulting construction projects, a municipality is able to achieve the required treatment to adhere to an enforceable permit condition.

Associated Terms and Phrases

Water quality based effluent limit (WQBEL or "Q-bell") are pre-TMDL discharge limits that wastewater facilities must meet in order not to create or contribute to an impairment.

Target

No specific numeric target exists in this measure. Clean Water Funds are provided as grants and loans to municipalities to build projects to provide additional wastewater and stormwater treatment in order to meet the more stringent discharge limits. The appropriations are available for a five year period because these projects are complex and require significant time for planning and design. For the past four years, all municipal entities that have applied and completed all program administrative requirements have been fully funded. The agencies are committed to meeting the entire demand resulting from permit limits that exceed secondary treatment standards due to the degraded water quality. Additionally, there are delays in construction because these projects are complex and require significant time for planning and design.

Baseline

No base year is needed for this measure.

Geographical Coverage

This measure has both statewide, basin and watershed impacts and protection or restoration investments.
Funding for this program is based on the ranking and points on the state's Clean Water Project Priority List (PPL) which prioritizes a variety of receiving waters criteria factors

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Data and Methodology

Methodology for Measure Calculation

There are a variety of pollutants (bacteria, mercury, chloride, nitrogen, phosphorus, etc.) that are addressed by CW funds for municipal projects. Pollutant reduction estimates are based, for the most part, on how projects are expected to function after initiation of operations. Currently pollution loading reductions is only calculated for phosphorus in wastewater projects.

Data Source

The data source for this measure is based on engineer calculations of future facility operation or documented facility operation.

Data Collection Period

Data used is from projects receiving an award in Fiscal Years 2010-2017. In some cases, longer time frames are used in order to establish trend lines or provide a more historical context to resulting environmental improvements.

Data Collection Methodology and Frequency

This is a brief description the calculation methods used for Point Source Implementation grant (PSIG) projects, where the pollutant of concern to be reduced is phosphorus, or phosphorus reductions estimates are desired for other pollutants of concern as an indicator of success of the project to show positive environmental benefits.

The before project annual phosphorus load value (pounds per year or lb/yr) in the spreadsheet tables came from a calculation using before project discharge monitoring report data (DELTA data from 2012 and now Tempo 360) for average daily phosphorus concentration and average daily flow.

The after project annual phosphorus load (lb/yr) calculations were prepared one of two ways. First, if the construction project has been completed with one full year of operation discharge monitoring report data available, the average daily phosphorus concentration and average daily flow were used to calculate the annual load (lb/yr). Second, if the construction project was not complete, the after project annual load was estimated using the permit phosphorus average daily concentration effluent limit (typically 1.0 mg/L or less) and the design average daily wet weather flow for the project location.

The projected reduction load calculation was then the before project calculated load minus the after project calculated load.

Please note: in two project cases the facilities getting mercury effluent limits (listed as mercury for the pollutant of concern) already had existing permit phosphorus effluent limits of 1.0 mg/L and were already reducing phosphorus at or below their required effluent phosphorus concentration limit. At these project locations, the construction project was not targeted at reducing phosphorus, but at reducing mercury. Both facilities are constructing new filtration systems that will likely reduce the particulate phosphorus in the facilities treated effluent, however it is not possible to quantify this potential reduction in effluent phosphorus at this time. The projected reduction load calculations for these two projects were assigned zero (0) lb/yr.

Phosphorus reduction estimates for the PSIG Projects that had Fecal Coliform as the identified pollutant of concern were calculated by selecting the number of failing onsite systems from their respective Project Priority List (PPL) applications, and assuming that there were 2.5 residents per home, and assigning a phosphorus load of 1.76 lb/person/day. The number of homes figure was then multiplied by 2.5 and by 1.76 to give an estimate of the possible phosphorus load per day that is estimated to be reduced from the receiving water at those project locations (assuming that those failing onsite systems were directly influencing that receiving water by a direct straight pipe discharge).

Supporting Data Set

Phosphorus load reduction from CWL point-source funding programs

2010 Projects Project Sponsor	Watershed	Projected Phosphorus Load Reduction (lb/yr)
Blue Earth - Phase 2	Blue Earth River	0
Comfrey	Minnesota River (Mankato)	158
Faribault	Cannon River	5,421
MCES Blue Lake Plant Improvements	Lower Minnesota River	9,664
Renville	Minnesota River (Yellow Medicine River)	8,012
St. Cloud - Phase 1	Mississippi River (St. Cloud)	4,355
St. James	Watonwan River	7,036

Waseca	Cannon River	0
Willmar - Phase 1b	Minnesota River (Yellow Medicine River)	55,315
Zimmerman	Mississippi River (St. Cloud)	173
2010 Total		90,134
2011 Projects		
Arlington	Lower Minnesota River	0
Butterfield	Watonwan River	0
Crystal - Stormwater	Mississippi River (Twin Cities)	120
Doran	Bois de Sioux River	32
Elmore	Blue Earth River	188
Essig	Cottonwood River	93
Forest City Twp	North Fork Crow River	18
Mantorville - Mantor Drive	Zumbro River	482
Marshall - Stormwater	Redwood River	1,062
Minneota	Minnesota River (Yellow Medicine River)	299
Odin	Watonwan River	(included in Ormsby)
Ormsby	Watonwan River	481
Owatonna	Cannon River	10,291
Pipestone	Lower Big Sioux River	1,069
Princeton	Rum River	0
Red Rock Twp - Nicolville	Cedar River	28
Watson	Chippewa River	116
Winnebago	Blue Earth River	0
2011 Total		14,279
2012 Projects		
Evansville	Chippewa River	65
Fosston	Clearwater River	2,331
Minneapolis - Stormwater	Mississippi River - Twin Cities	20
Minnesota City	Mississippi River - Winona	14
North Koochiching Area SD	Rainy River - Black River	0
RWMWD - Stormwater	Mississippi River - Twin Cities	29
Starbuck	Chippewa River	407
Virginia	St. Louis	3,906
2012 Total		6,772

2013 Projects		
Hibbing	St. Louis	0
Lansing Twp	Cedar River	66
Roseland Twp	Minnesota River - Yellow Medicine River	194
Steele County - Bixby	Cannon River	84
2013 Total		344
2014 Projects		
Cambridge	Rum	10,451
Dundee	Des Moines River - Headwaters	183
Mankato - Knollwood Park	Minnesota River - Mankato	171
Mankato - Stormwater	Minnesota River - Mankato	84
Northrop	Blue Earth River	0
Oronoco Twp - Kings Park	Zumbro River	110
Prior Lake (Spring Lake Twp)	Lower Minnesota River	167
Raymond	Minnesota River - Yellow Medicine River	0
Rice County - Roberds Lake	Cannon River	1,245
St. Anthony - Stormwater	Mississippi River - Sartell	26
2014 Total		12,437
2015 Projects		
Austin - Turtle Creek 1	Cedar River	128
Biscay	South Fork Crow River	0
Fillmore County - Greenleafton	Root River	167
Hayfield	Zumbro River	1,172
Hayward	Shell Rock River	0
Hazel Run	Minnesota River - Yellow Medicine River	141
Mankato - Schaefers Addition	Cannon River	286
Minnehaha Creek WD - Stormwater	Mississippi River - Twin Cities	0
Mora	Snake River	2,819
Prior Lake - Mushtown	Lower Minnesota River	154
Rockford	North Fork Crow	2,094
2015 Total		6,961
2016 Projects		

Big Lake	Mississippi River – St. Cloud	855
Elk River	Mississippi River – St. Cloud	2,425
Monticello	Mississippi River – St. Cloud	10,452
2016 Total		13,732
2017 Projects		
Minneota	Minnesota River – Yellow Medicine	0
Oronoco Twp – Cedar Beach	Zumbro River	88
St. Francis	Rum River	0
Jackson	Des Moines River – Headwaters	119
Afton	Lower St. Croix River	163
2017 Total		370
Cumulative Total		145,029

Caveats and Limitations

- This measure only tracks projects implemented with funding from Clean Water Fund Grants.
- Projects that record zero pounds of phosphorus removed are a result of an expansion in treatment capacity while still operating the facility at less than design flows.

Future Improvements

Additional data measures will be developed to address the two other pollutants – fecal coliform (bacteria) and mercury. Cost per pollutant unit removed may also consider if there is value in pursuing that type of performance indicator.

Financial Considerations

Contributing Agencies and Funding Sources

Not applicable

Communication Strategy

Target Audience

Municipal entities

Measure Points of Contact

Agency Information

Bill Dunn
Clean Water Revolving Fund Coordinator
Minnesota Pollution Control Agency
520 Lafayette Road North
Saint Paul, MN 55155
Phone 651/757-2324
Fax 651/297-8676

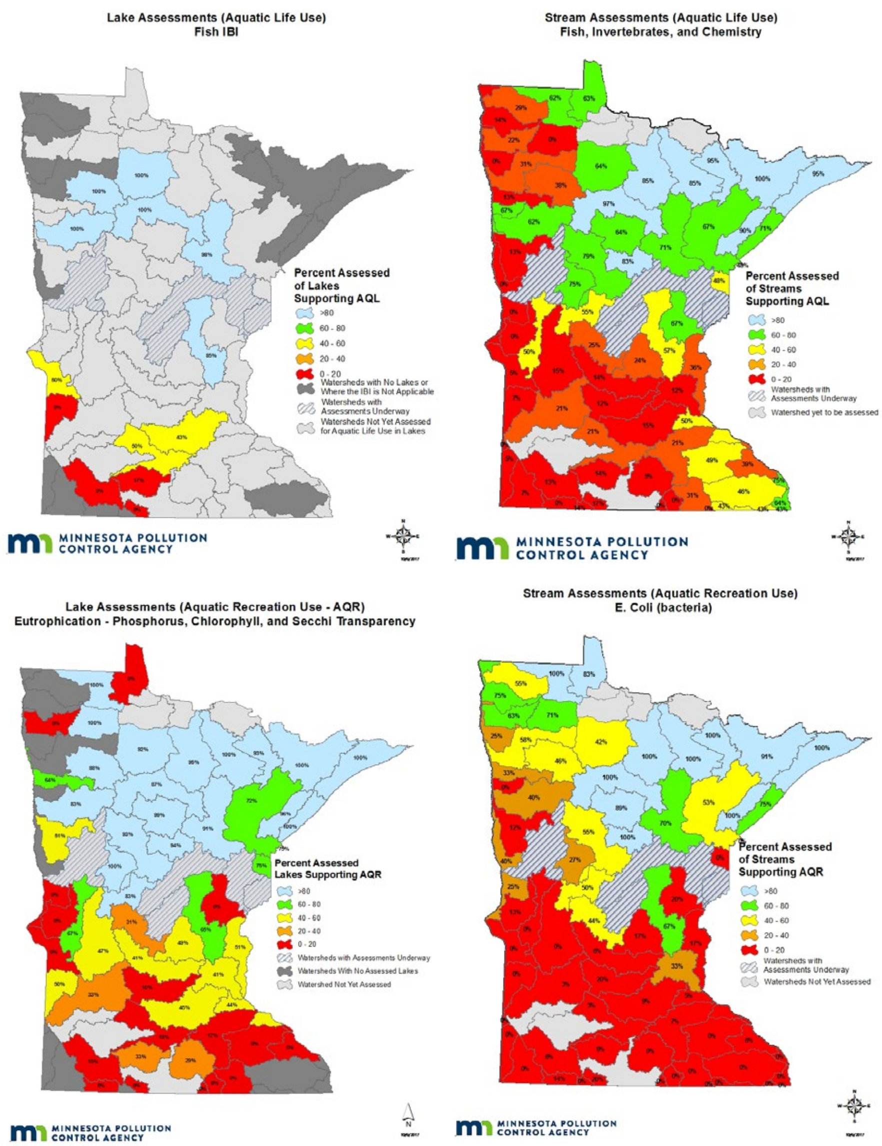
bill.dunn@state.mn.us
www.pca.state.mn.us/ppl

Jeff Freeman |Executive Director
Minnesota Public Facilities Authority
1st National Bank Building
332 Minnesota Street, Suite W820
St. Paul, MN 55101
651-259-7465
jeff.freeman@state.mn.us
https://mn.gov/deed/pfa/

Surface Water Health: Statewide and watershed impairment/unimpairment rate

Measure Background

Visual Depiction



Measure Description

The intent of this measure is to communicate the impairment "rate" of lakes and streams, by designated use, statewide and also by watershed. While we have the ability to report data for each main category of designated use for which we have standards, the focus at least initially will be on aquatic recreation and aquatic life use for lakes and stream. This measure will be presented at statewide and watershed scales, with a separate map for each use/resource type combination (i.e., aquatic recreation/lakes, aquatic recreation/streams, etc.).

Associated Terms and Phrases

Assessment: The process of summarizing the biological, chemical and physical data available for a lake or stream site and comparing the data against water quality standards to determine if designated uses are supported.
Condition monitoring: Monitoring the background, or ambient, condition of a lake or stream reach. This type of monitoring typically requires monitoring once or twice per month during the open water season for a minimum of two years. The resulting data are compared to state and federal water quality standards put in place to support various uses (drinking water, aquatic recreation, aquatic life, consumption, etc.) to determine if the resource is exceeding standards (i.e., is "impaired") and in need of restoration or is meeting standards and in need of protection.
Designated use: The identified use for which a waterbody is managed (support of aquatic communities, recreation in or on the water, consuming the water or fish taken from the water).
Impairment: One or more designated use is not being met, as determined by a comparison to applicable water quality standards.
Impairment rate: Percentage of lakes or streams impaired for a specific designated use (statewide, or watershed-by-watershed).
Intensive watershed monitoring (IWM): A ten-year rotational cycle wherein an average of 8 of Minnesota's 80 major (8-digit hydrologic unit code) watersheds are intensively monitored each year. During intensive watershed monitoring, additional focus is placed on monitoring the outlets of subwatersheds (aggregated 12 -digit hydrologic unit code) for biota (fish and invertebrates) and physical habitat, and to sample for chemical parameters ten times. One-time biological, physical and chemical sampling is also conducted at the outlet of the 14-digit hydrologic unit code watersheds. During intensive watershed monitoring, all accessible lakes ≥500 acres and at least 25% of lakes 100-499 acres are monitored for physical and chemical parameters. The Minnesota Department of Natural Resources leads the monitoring for fish and plants, and starting with 2013 IWM watershed start years, lakes were sampled for and assessed against the Lake Fish IBI.
Major watershed: 8-digit hydrologic unit code (HUC) watersheds in Minnesota; there are 80 in Minnesota.

Target

Ultimately, the target is 100% of Minnesota's waters supporting designated uses, or a 0% impairment "rate" for all designated uses.

Baseline

Five watersheds (those monitored intensively in 2007 and three in 2008) were comprehensively assessed in 2010 to pilot a new assessment process. Eleven more watersheds were assessed in 2011. On average, eight watersheds are expected to be assessed annually with the entire state completed with the 2019 water quality assessments.

Geographical Coverage

Statewide and watershed.

Data and Methodology

Methodology for Measure Calculation

We will calculate the impairment "rate" for each designated use for which we have data by dividing the total number of resources assessed by those resources not meeting standards. For example, the impairment rate for aquatic recreation for lakes will be the total number of lakes that we assessed in a watershed divided by the number of those lakes found to be impaired for aquatic recreational use support. The statewide rate will be calculated by adding the total number of lakes assessed divided by the number of lakes statewide found to be impaired for aquatic recreational use support. Assessment data are queried from the MPCA's Assessment database (ADB) and combined with lake/stream and watershed information found in Core_WU tables. The assessment results are summarized in a spreadsheet (AssessmentMeasures.xls), which is loaded into an Access database (AssessmentMeasures.mdb). The tables in this database are joined to four separate GIS projects each July to develop the statewide maps showing watershed assessment results. AssessmentMeasures.xls, AssessmentMeasures.mdb and the GIS projects can all be found in X:\Agency_Files\Water\Condition Monitoring\Measures\Lakes & Streams\EDWOM1_ImpairmentUnimpairment Rate on the MPCA's server. Detailed methods for querying database systems for the assessment data, manipulating it and loading it to the GIS projects are also found in Measures Reporting Notes.docx link in this folder.

Data Source

The MPCA's Assessment database (or ADB) stores results of the MPCA's annual assessments. Lake/stream watershed information is found in MPCA's Core_WU data tables.

Data Collection Period

The MPCA uses the most recent ten years of monitoring data in the EQuIS surface water data management database when assessing a lake or stream reach. Monitoring data are collected by the MPCA annually with each major watershed intensively sampled every 10 years. The majority of monitoring occurs in the year we start intensively monitoring a given watershed (all biological, half of the chemical); additional sampling for water chemistry occurs in the following year. Additional data comes into EQuIS (the state's water quality data management system) from a variety of state, local and citizen partners from their own monitoring efforts and programs, which follow various schedules (i.e., may be a one year sampling project or an ongoing monitoring effort, etc.). These externally collected data are also used to assess lake and stream condition, if this data meets the MPCA's quality standards.

Data Collection Frequency

On average, eight watersheds are comprehensively assessed each winter, and assessment maps are updated each July.

Supporting Data Set

Stream aquatic life and aquatic recreation assessment data:

Watersheds	AQL NS (count/%)	AQL FS (count/%)	Assessed AQL Streams (count)	AQR NS (count/%)	AQR FS (count/%)	Assessed AQR Streams (count)
Lake Superior – North 04010101	3 (5%)	60 (95%)	63	0 (0%)	18 (100%)	18
Lake Superior - South 04010102	11 (29%)	27 (71%)	38	3 (25%)	9 (75%)	12
St. Louis River 04010201	24 (33%)	49 (67%)	73	17 (46%)	20 (54%)	37
Cloquet River 04010202	3 (10%)	27 (90%)	30	0 (0%)	6 (100%)	6
Nemadji River 04010301	11 (52%)	10 (48%)	21	2 (100%)	0 (0%)	2
Mississippi River Headwaters 07010101	1 (3%)	36 (97%)	37	0 (0%)	11 (100%)	11
Leech Lake River 07010102	5 (36%)	9 (64%)	14	1 (11%)	8 (89%)	9
Mississippi River Grand Rapids 07010103	18 (29%)	44 (71%)	62	6 (30%)	14 (70%)	20
Mississippi River –Brainerd 07010104						
Pine River 07010105	4 (17%)	20 (83%)	24	0 (0%)	9 (100%)	9
Crow Wing River 07010106	10 (24%)	31 (76%)	41	10 (43%)	13 (57%)	23
Redeye River 07010107	4 (25%)	12 (75%)	16	8 (73%)	3 (27%)	11
Long Prairie River 07010108	10 (45%)	12 (55%)	22	3 (50%)	3 (50%)	6
Mississippi River – Sartell 07010201						
Sauk River 07010202	22 (71%)	9 (29%)	31	14 (56%)	11 (44%)	25
Mississippi River (St. Cloud) 07010203	17 (77%)	5 (23%)	22	20 (83%)	4 (17%)	24

North Fork Crow River 07010204	19 (86%)	3 (14%)	22	15 (94%)	1 (6%)	16
Watersheds	AQL NS (count/%)	AQL FS (count/%)	Assessed AQL Streams (count)	AQR NS (count/%)	AQR FS (count/%)	Assessed AQR Streams (count)
South Fork Crow River 07010205	46 (88%)	6 (12%)	52	12 (80%)	3 (20%)	15
Mississippi River (Twin Cities) 07010206	26 (79%)	7 (21%)	33	20 (69%)	9 (31%)	29
Rum River 07010207	18 (43%)	24 (57%)	42	5 (33%)	10 (67%)	15
Minnesota River – Headwaters 07020001	19 (95%	1 (5%)	20	15 (100%)	0 (0%)	15
Pomme de Terre River 07020002	6 (50%)	6 (50%)	12	2 (100%)	0 (0%)	2
Lac Qui Parle River 07020003	27 (93%)	2 (7%)	29	16 (100%)	0 (0%)	16
Minnesota River (Granite Falls) 07020004	30 (83%)	6 (17%)	36	30 (97%)	1 (3%)	31
Chippewa River 07020005	22 (85%)	4 (15%)	26	22 (100%)	0 (0%)	22
Redwood River (07020006)						
Minnesota River – Mankato 07020007	54 (79%)	14 (21%)	68	35 (97%)	1 (3%)	36
Cottonwood River 07020008						
Blue Earth River 07020009						
Watonwan River 07020010	32 (86%)	5 (14%)	37	15 (94%)	1 (6%)	16
Le Sueur River 07020011	20 (95%)	1 (5%)	21	8 (100%)	0 (0%)	8
Lower Minnesota River 07020012	84 (85%)	15 (15%)	99	51 (91%)	5 (9%)	56

Watersheds	AQL NS (count/%)	AQL FS (count/%)	Assessed AQL Streams (count)	AQR NS (count/%)	AQR FS (count/%)	Assessed AQR Streams (count)
Upper St. Croix 07030001						
Kettle River 07030003						
Snake River 07030004	14 (33%)	28 (67%)	42	8 (80%)	2 (20%)	10
St. Croix River (Stillwater) 07030005	16 (57%)	12 (43%)	28	19 (83%)	4 (17%)	23
Mississippi River (Red Wing) 07040001	8 (53%)	7 (47%)	15	19 (95%)	1 (5%)	20
Cannon River 07040002	40 (77%)	12 (43%)	52	43 (93%)	3 (7%)	46
Mississippi River (Winona) 07040003	19 (59%)	13 (41%)	32	15 (94%)	1 (6%)	16
Zumbro River 07040004	34 (51%)	33 (49%)	67	23 (100%)	0 (0%)	23
Mississippi River – La Crescent 07040006	1 (25%)	3 (75%)	4	1 (100%)	0 (0%)	1
Root River 07040008	45 (54%)	38 (46%)	83	20 (100%)	0 (0%)	20
Mississippi River – Reno 07060001	4 (36%)	7 (64%)	11	2 (100%)	0 (0%)	2
Upper Iowa River 07060002	8 (57%)	6 (43%)	14	5 (100%)	0 (0%)	5
Upper Wapsipinicon River 07080102	1 (100%)	0 (0%)	1	1 (100%)	0 (0%)	1
Cedar River 07080201	24 (69%)	11 (31%)	35	16 (100%)	0 (0%)	16
Shell Rock River 07080202	2 (100%)	0 (0%)	2	3 (100%)	0 (0%)	3

Watersheds	AQL NS (count/%)	AQL FS (count/%)	Assessed AQL Streams (count)	AQR NS (count/%)	AQR FS (count/%)	Assessed AQR Streams (count)
Winnebago River 07080203	4 (100%)	0 (0%)	4	1 (100%)	0 (0%)	1
Des Moines River – Headwaters 07100001	48 (87%)	7 (13%)	56	16 (94%)	1 (6%)	17
Lower Des Moines River 07100002	6 (86%)	1 (14%)	7	1 (100%)	0 (0%)	1
E Fork Des Moines River 07100003	5 (83%)	1 (17%)	6	4 (80%)	1 (20%)	5
Bois de Sioux River 09020101	7 (100%)	0 (0%)	7	3 (75%)	1 (25%)	4
Mustinka River 09020102	13 (100%)	0 (0%)	13	7 (88%)	1 (12%)	8
Ottertail River 09020103						
Red River of the North (Headwaters) 09020104	6 (100%)	0 (0%)	6	5 (1%)	0 (0%)	5
Buffalo River 09020106	14 (88%)	2 (12%)	16	22 (88%)	3 (12%)	25
Red River of the N – Marsh River 09020107	2 (33%)	4 (67%)	6	1 (100%)	0 (0%)	1
Wild Rice River 09020108	13 (38%)	21 (62%)	34	15 (60%)	10 (40%)	25
Red River of the North - Sandhill River 09020301	7 88%)	1 (12%)	8	4 (67%)	2 (33%)	6
Upper/Lower Red Lake 09020302	10 (36%)	18 (64%)	28	11 (58%)	8 (42%)	19
Red Lake River 09020303	20 (69%)	9 (31%)	29	8 (42%)	11 (58%)	19
Thief River 09020304	3 (100%)	0 (0%)	3	2 (29%)	5 (71%)	7

Watersheds	AQL NS (count/%)	AQL FS (count/%)	Assessed AQL Streams (count)	AQR NS (count/%)	AQR FS (count/%)	Assessed AQR Streams (count)
Clearwater River 09020305	20 (63%)	12 (38%)	32	15 (54%)	13 (46%)	28
Red River - Grand Marais Creek 09020306	7 (100%)	0 (0%)	7	3 (75%)	1 (25%)	4
Snake River 09020309	14 (78%)	4 (22%)	18	3 (38%)	5 (63%)	8
Tamarac River (Red River of the North) 09020311	5 (83%)	1 (17%)	6	1 (25%)	3 (75%)	4
Two Rivers 09020312	15 (71%)	6 (29%)	21	5 (45%)	6 (55%)	11
Roseau River 09020314	5 (38%)	8 (62%)	13	0 (0%)	5 (100%)	5
Rainy River Headwaters (09030001)	0 (100%)	54 100%)	54	1 (9%)	10 (91%)	11
Vermilion River 09030002	1 (5%)	20 (95%)	21	0 (0%)	9 (100%)	
Rainy River-Rainy Lake 09030003						
Little Fork River 09030005	6 (15%)	33 (85%)	39	0 (0%)	12 (100%)	12
Big Fork River 09030006	6 (15%)	33 (85%)	39	0 (0%)	11 (100%)	11
Rapid River 09030007						
Rainy River – Lower 09030008						
Lake of the Woods 09030009	6 (38%)	10 (63%)	16	1 (17%)	5 (83%)	6
Upper Big Sioux River 10170202	1 (100%)	0 (0%)	1	0 (0%)	0 (0%)	0
Lower Big Sioux River 10170203	19 (95%)	1 (5%)	20	7 (100%)	0 (0%)	7

Watersheds	AQL NS (count/%)	AQL FS (count/%)	Assessed AQL Streams (count)	AQR NS (count/%)	AQR FS (count/%)	Assessed AQR Streams (count)
Rock River 10170204	27 (93%)	2 (7%)	29	18 (100%)	0 (0%)	18
Little Sioux River 10230003	4 (100%)	0 (0%)	4	6 (86%)	1 (14%)	7

AQL = aquatic life; AQR = aquatic recreation; NS = non-support for designated uses; FS = full support for designated uses

Lake aquatic life and aquatic recreation assessment data:

Watersheds	AQL Lakes NS (count/%)	AQL Lakes FS (count/%)	Count	AQR Lakes NS (count/%)	AQR Lakes FS (count/%)	Count
Lake Superior - North 04010101				0 (0%)	79 (10%)	79
Lake Superior - South 04010102				0 (0%)	6 (100%)	6
St. Louis River 04010201				7 (28%)	18 (72%)	25
Cloquet River 04010202				1 (4%)	27 (96%)	28
Nemadji River 04010301				2 (25%)	6 (75%)	8
Mississippi River - Headwaters 07010101	0 (0%)	46 (100%)	46	15 (13%)	102 (87%)	117
Leech Lake River 07010102				1 (1%)	80 (99%)	81
Mississippi River - Grand Rapids 07010103	1 (2%)	46 (100%)	47	11 (9%)	106 (91%)	117
Mississippi River – Brainerd 07010104				9 (19%)	38 (81%)	47
Pine River 07010105				5 (6%)	77 (94%)	82
Crow Wing River 07010106				8 (7%)	106 (93%)	114
Redeye River 07010107				0 (0%)	14 (100%)	14
Long Prairie River 07010108	3 (100%)	0 (0%)	3	10 (17%)	50 (83%)	60
Mississippi River - Sartell 07010201				3 (18%)	14 (82%)	17
Sauk River 07010202				31 (69%)	14 (31%)	45
Mississippi River (St. Cloud) 07010203				35 (51%)	34 (49%)	69

Watersheds	AQL Lakes NS (count/%)	AQL Lakes FS (count/%)	Count	AQR Lakes NS (count/%)	AQR Lakes FS (count/%)	Count
North Fork Crow River 07010204				41 (59%)	29 (41%)	70
South Fork Crow River 07010205				35 (90%)	4 (10%)	39
Mississippi River (Twin Cities) 07010206	26 (100%)	0 (0%)	26	89 (59%)	63 (41%)	152
Rum River 07010207	2 (14%)	12 (86%)	14	14 (35%)	26 (65%)	40
Minnesota River - Headwaters 07020001	1 (50%)	1 (50%)	2	5 (100%)	0 (0%)	5
Pomme de Terre River 07020002				4 (33%)	8 (67%)	12
Lac Qui Parle River 07020003	1 (100%)		1	1 (50%)	1 (50%)	2
Minnesota River (Granite Falls) 07020004				14 (67%)	7 (33%)	21
Chippewa River 07020005				34 (53%)	30 (47%)	64
Redwood River 07020006				4 (80%)	1 (20%)	5
Minnesota River - Mankato 07020007	2 (50%)	2 (50%)	4	9 (82%)	2 (18%)	11
Cottonwood River 07020008				4 (100%)	0 (0%)	4
Blue Earth River 07020009				7 (100%)	0 (0%)	7
Watonwan River 07020010	5 (83%)	1 (17%)	6	4 (67%)	2 (33%)	6
Le Sueur River 07020011				5 (71%)	2 (29%)	7

Watersheds	AQL Lakes NS (count/%)	AQL Lakes FS (count/%)	Count	AQR Lakes NS (count/%)	AQR Lakes FS (count/%)	Count
Lower Minnesota River 07020012	8 (57%)	6 (43%)	14	55 (55%)	45 (45%)	100
Upper St. Croix River 07030001				0 (0%)	1 (100%)	1
Kettle River 07030003				1 (11%)	8 (89%)	9
Snake River 07030004				6 (100%)	0 (0%)	6
St. Croix River (Stillwater) 07030005				52 (49%)	55 (51%)	107
Mississippi River (Red Wing) 07040001				5 (56%)	4 (44%)	9
Cannon River 07040002				36 (88%)	5 (12%)	41
Mississippi River (Winona) 07040003				2 (100%)	0 (0%)	2
Zumbro River 07040004						
Mississippi River - La Crescent 07040006						
Root River 07040008						
Mississippi River - Reno 07060001						
Upper Iowa River 07060002						
Upper Wapsipinicon River 07080102						
Cedar River 07080201				1 (100%)	0 (0%)	1
Shell Rock River 07080202				5 (100%)	0 (0%)	5

Watersheds	AQL Lakes NS (count/%)	AQL Lakes FS (count/%)	Count	AQR Lakes NS (count/%)	AQR Lakes FS (count/%)	Count
Winnebago River 07080203				2 (100%)	0 (0%)	2
Des Moines River - Headwaters 07100001	10 (100%)	0 (0%)	10	19 (90%)	2 (10%)	21
Lower Des Moines River 07100002						
East Fork Des Moines River 07100003	2 (100%)	0 (0%)	2	4 (100%)	0 (0%)	4
Bois de Sioux River 09020101				3 (100%)	0 (0%)	3
Mustinka River 09020102				3 (100%)	0 (0%)	3
Otter Tail River 09020103				4 (4%)	94 (96%)	97
Red River of the North (Headwaters) 09020104						
Buffalo River 09020106				17 (49%)	18 (51%)	35
Red River of the North - Marsh River 09020107						
Wild Rice River 09020108	0 (0%)	10 (100%)	10	2 (17%)	10 (83%)	12
Red River of the North - Sandhill River 09020301				4 (36%)	7 (64%)	11
Upper/Lower Red Lake 09020302	0 (0%)	5 (100%)	5	5 (8%)	55 (92%)	60
Red Lake River 09020303						
Thief River 09020304				0 (0%)	1 (100%)	1

Watersheds	AQL Lakes NS (count/%)	AQL Lakes FS (count/%)	Count	AQR Lakes NS (count/%)	AQR Lakes FS (count/%)	Count
Clearwater River 09020305	0 (0%)	9 (100%)	9	3 (12%)	23 (88%)	26
Red River - Grand Marais Creek 09020306						
Snake River 09020309				6 (100%)	0 (0%)	6
Tamarac River (Red River of the North) 09020311						
Two Rivers 09020312						
Roseau River 09020314				0 (0%)	1 (100%)	1
Rainy River - Headwaters 09030001				1 (0%)	237 (100%)	238
Vermilion River 09030002				2 (7%)	27 (93%)	29
Rainy River - Rainy Lake 09030003				0 (0%)	1 (100%)	1
Little Fork River 09030005				0 (0%)	15 (100%)	15
Big Fork River 09030006				6 (5%)	111 (95%)	117
Rapid River 09030007						
Rainy River - Lower 09030008						
Lake of the Woods 09030009				2 (100%)	0 (0%)	2
Upper Big Sioux River 10170202						

Watersheds	AQL Lakes NS (count/%)	AQL Lakes FS (count/%)	Count	AQR Lakes NS (count/%)	AQR Lakes FS (count/%)	Count
Lower Big Sioux River 10170203						
Rock River 10170204						
Little Sioux River 10230003				9 (100%)	0 (0%)	9

AQR = aquatic recreation; NS = non-support for designated uses; FS = full support for designated uses
Shaded cells do not have lakes available for assessment.

Caveats and Limitations

We do not randomly select the watersheds or sites/lakes that are intensively monitored, so the impairment/unimpairment rates must be characterized as representative of the body of lakes or streams sampled. The rates cannot be characterized as an unbiased statewide picture of lake and stream condition.

Also, the watersheds assessed to date are largely located in central and southern Minnesota. Since water quality in lakes and streams alike tends to be more degraded in central and southern Minnesota than in the north, the statewide rates will be skewed towards high impairment rates until we have assessed more watersheds in northern Minnesota. The rates may always be biased towards impairment, as a portion of the monitoring conducted on the state and local level is aimed at resources that are suspected to have pollution problems.

Sites and lakes are delisted as water integrity is restored or as corrections to the impaired waters list are made. For this reason, we may see impairment/unimpairment rates change for a given watershed from one year to the next, and we also expect to see impaired rates diminish over time for some watersheds. This measure reflects the lakes and stream reach assessment decisions made for those resources for which we have sufficient data for assessment and whose datasets allow us to make a clear assessment decision. Each year, there are a number of resources for which the assessment data indicates the resource is hovering near the impairment thresholds. In such cases, we delay an assessment decision to allow additional time to gather more data.

Future Improvements

As new standards or tools are available, we will be able to report additional impairment/unimpairment results.

Financial Considerations

Contributing Agencies and Funding Sources

Funding for core monitoring that supports the MPCA's Intensive Watershed Monitoring design comes from the Minnesota Clean Water Fund, though it should be noted that the MPCA considers all surface water monitoring data stored in EQuIS when assessing the condition of Minnesota's lakes and streams. Additional data beyond that collected through the IWM design is collected through local and other state programs supported by Clean Water and non-Clean Water Funds. For example, a lake association may monitor their lake annual through member dues and submit these data to EQuIS.

Communication Strategy

Target Audience
Local, state and federal agencies and the general public.

Associated Messages
This measure conveys our progress in assessing lakes and streams statewide. Since restoration and protection planning work follows condition monitoring and assessment, this measure also conveys to other MPCA staff and local partners when restoration and protection planning may begin in their regions. This measure also has enormous interest for citizens who want to know how resources in their area are faring. The impairment/unimpairment rates must be carefully understood, though, as they come with many caveats (see Caveats and Limitations). The impairment/unimpairment rate does not provide any direct information on resources that have been delisted, so this measure alone gives no real sense of progress being made to improve water quality.

Outreach Format
TBD.

Other Measure Connections
This measure replicates the MPCA strategic measure on impairment and unimpairment rates in Minnesota.

Measure Points of Contact

Agency Information
Pam Anderson, MPCA, Water Quality Monitoring Unit supervisor, pam.anderson@state.mn.us.

Changes over time in key water quality parameters for lakes and streams

Measure Background

Measure Description

Trend monitoring, routinely sampling a lake or stream site for years, helps determine true water quality/biological change over time, as opposed to short-term changes due to natural variability (drought, excess rain, cooler/warmer than average temperatures, etc.). Due to cost and logistical considerations, only a small percentage of Minnesota's lakes and streams can be monitored routinely, but those that are provide an excellent understanding of long-term change over time. This measure features a variety of graphics intended to show changes over time in the chemical, biological and physical characteristics of lakes and streams.

We have selected several monitoring programs to provide water quality information to detect the changes in lake and stream water quality in Minnesota over time. Annually, we will be reporting statewide trends from the MPCA's Citizen Lake and Stream Monitoring Programs, a network of over 1000 volunteers submitting water clarity measurements on lakes and streams. The MPCA's Major Watershed Load Monitoring network, consisting of 199 river and stream water quality and streamflow stations, will provide pollutant trends reflective of changes in watershed condition. Pesticide detection and concentration trends from the Minnesota Department of Agriculture (MDA) will be available for streams, rivers, and lakes from agricultural areas. The MPCA has been conducting comprehensive lake and stream condition monitoring by major watershed on a 10-year rotational basis since 2008 (piloted in 2006 and 2007). Every ten years, we will be able to report on changes in water quality to a watershed since the last time it was monitored, including change in time for biological communities. For each resource type (lake and stream), we have chosen to track key indicators of pollution.

The differing types of water resources, key parameters and temporal scales combine to create enough complexity to warrant breaking this measure into two major categories. Those categories are:

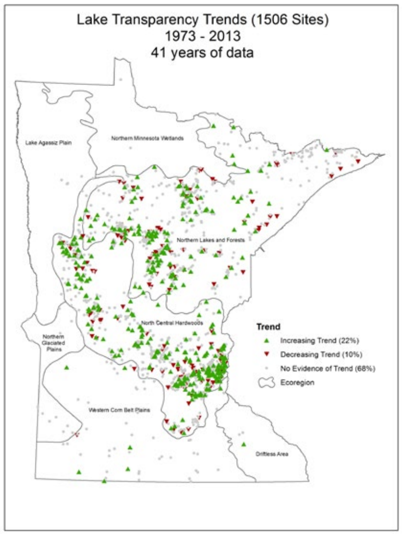
EDWOM 2a) Changes in lakes over time in total phosphorus, chlorophyll-a, transparency and pesticides (this category includes Citizen Lake Monitoring); and

EDWOM 2b) Changes in streams over time in nitrite-nitrate, total suspended solids, total phosphorus, and pesticides (this category includes Citizen Stream Monitoring).

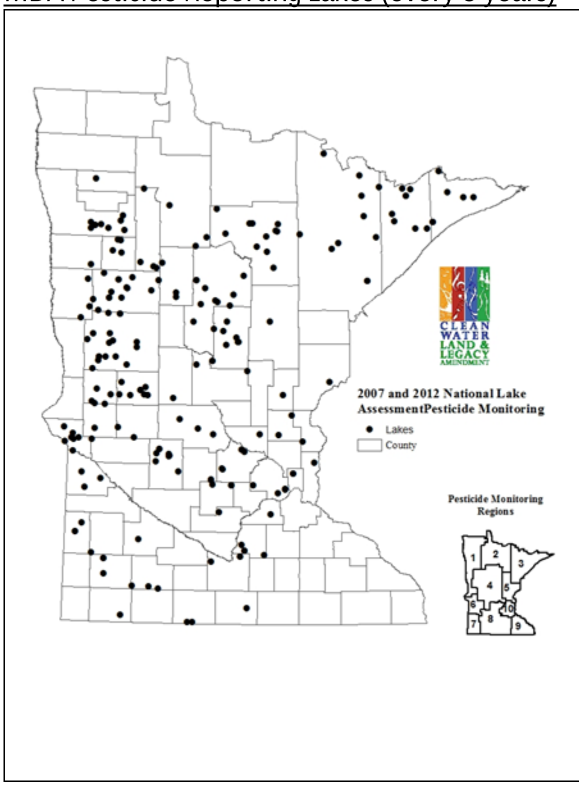
Visual Depiction

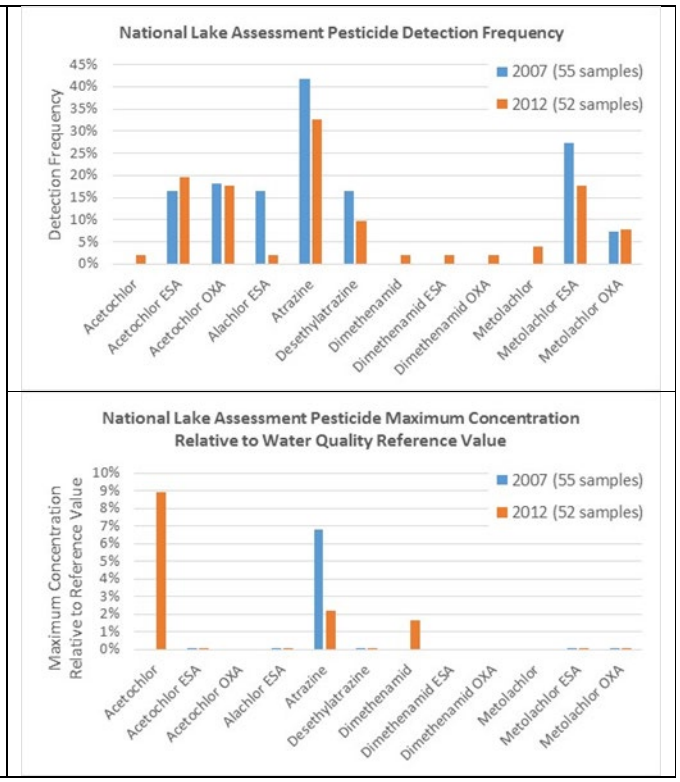
EDWOM 2a) Changes in lakes over time in total phosphorus, chlorophyll-a, and transparency, and pesticides

Annual reporting (Citizen Monitoring Program data – long term trends for Secchi Transparency)



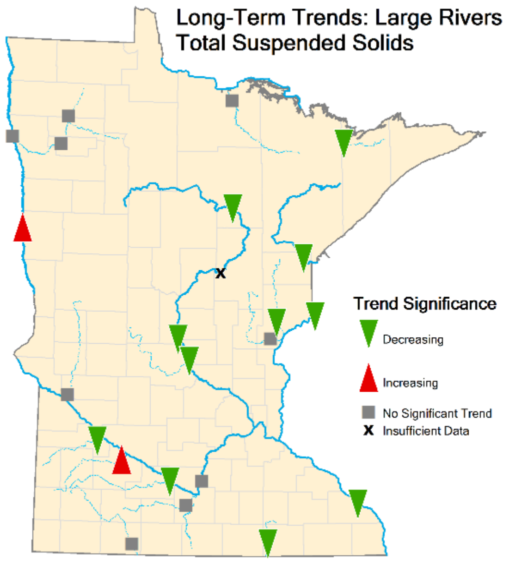
MDA Pesticide Reporting Lakes (every 5 years)

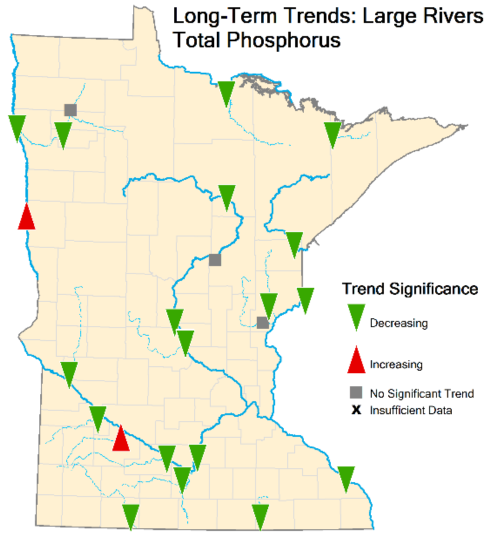


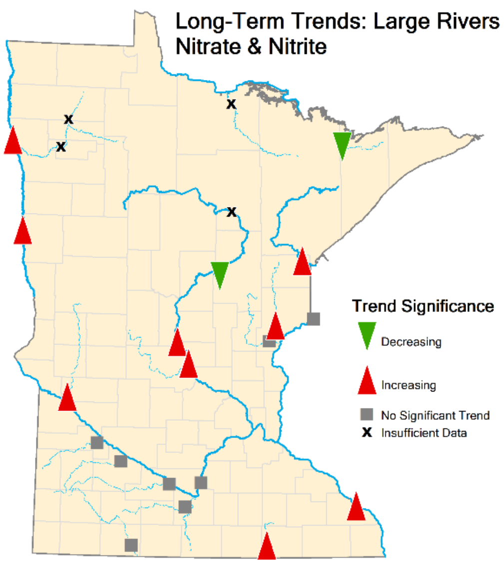


EDWOM 2b) Changes in streams over time in nitrite-nitrate, total suspended solids, total phosphorus, and pesticides

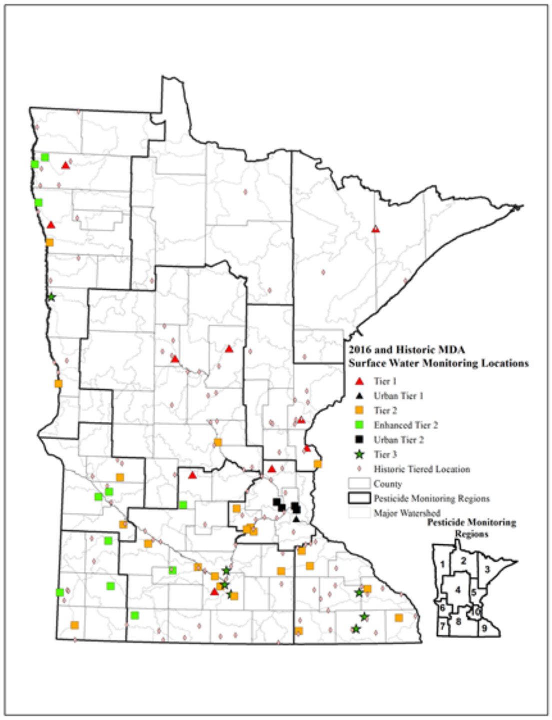
Annual Reporting (long-term trends for concentration in total suspended solids, total phosphorus, and nitrate + nitrite

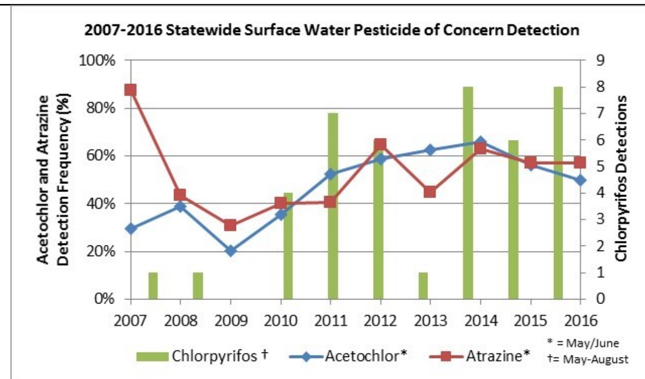

Long-Term Trends: Large Rivers
Total Suspended Solids
Trend Significance
Decreasing
Increasing
No Significant Trend
Insufficient Data

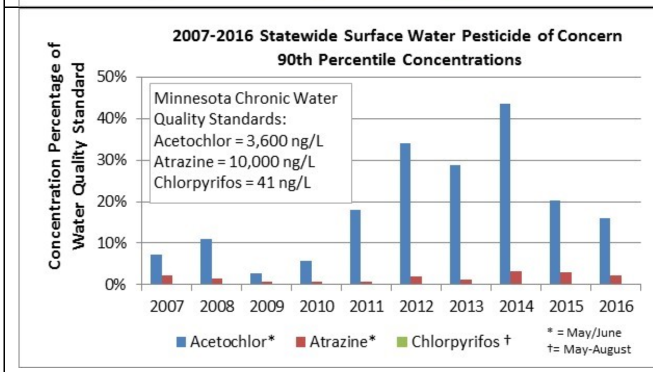

Long-Term Trends: Large Rivers
Total Phosphorus
Trend Significance
Decreasing
Increasing
No Significant Trend
Insufficient Data


Long-Term Trends: Large Rivers
Nitrate & Nitrite
Trend Significance
Decreasing
Increasing
No Significant Trend
Insufficient Data

MDA Annual Pesticide Reporting Streams and Rivers







Every ten years (Change over time in biological communities based on repeated condition monitoring):
Starting in 2020, as major watersheds are revisited, MPCA will be able to complete statistical analysis on biological monitoring results to determine if a change in scores over time can be detected in a given watershed. Methods for completing this work are in development.

Associated Terms and Phrases

Citizen Monitoring Programs (CMP): Programs supported by the MPCA where citizen volunteers collect water transparency data weekly during the open-water season on a lake or stream site of their choice. The Citizen Lake Monitoring Program has been operating since 1973. The Citizen Stream Monitoring Program has been operating since 1998. For many waters, transparency data may be the only available data to determine waterbody health.

Condition Monitoring: Monitoring the stream outlets of subwatersheds for biota (fish and invertebrates) and physical habitat, and water chemistry. Lakes greater than 500 acres and a portion of lakes 100-499 acres are monitored for physical and chemical parameters and a portion of those greater than 100 acres are monitored for lake fish IBI. Work is organized around a ten-year rotational cycle wherein approximately 8 of Minnesota's 80 major (8-digit hydrologic unit code) watersheds are monitored each year.

Hydrologic Discharge: The volume of water moving through a river or stream at any given time. Hydrologic discharge is typically reported in units of cubic feet per second in the United States.

Index of biological integrity (IBI): A measure of biological health based on a community assemblage such as fish, invertebrates or plants. IBIs are used to gauge the biological health of streams, lakes and wetlands.

Load monitoring: Monitoring is conducted at least monthly, and then more frequently during events (i.e., snowmelt or rain events). The objective is to capture the entire hydrograph, and to determine the pollutant load carried by a stream or river. MPCA and DNR support a network of 199 sites across Minnesota with stream chemistry and streamflow monitoring occurring annually.

Major watershed: 8-digit hydrologic unit code (HUC) watersheds in Minnesota; there are 80 in Minnesota.

National Aquatic Resource Surveys: Surveys of the nation's aquatic resources that are financially supported and coordinated by the U.S. Environmental Protection Agency. Often referred to as probability-based (or probabilistic) studies, these surveys provide nationally consistent and scientifically-defensible assessments of our nation's waters and can be used to track changes in condition over time. Each survey uses standardized field and lab methods and is designed to yield unbiased estimates of the condition of the whole water resource being studied. Each year, the U.S. EPA focuses on a different resource (i.e., rivers/ streams, lakes, wetlands, and coastal waters). The surveys are intended to be repeated every five years. MPCA has chosen to add to the NARS survey for lakes; for stream and wetland the enhancement is completely separate from the draw for the NARS study and uses Minnesota specific monitoring protocols and does not incorporate the NARS data in our analysis.

Pollutant concentration: Mass of a given pollutant per unit volume of water. Concentration is typically expressed in milligrams per liter.

Probabilistic study: A study where sampling sites are selected randomly, so the resulting data are unbiased and can be used to generalize conditions for a given region.

Surface Water Pesticide of Concern: A pesticide determined by the MDA Commissioner to have increased frequency of detection and elevated concentrations relative to applicable water quality reference values, in Minnesota's surface waters. The determination prompts MDA in developing chemical specific voluntary Best Management Practices (BMPs) for applicators to use when applying the pesticide.

Trend: Statistically significant improvement, no change or decline in a water quality parameter (chemistry concentrations or biological scores).

Target

Impaired lakes or streams: Decreasing trend for chemical parameters, increasing IBI and transparency trend.

Unimpaired lakes or streams: Decreasing or stable (no change) trend for chemistry, increasing or stable IBI and transparency.

Baseline

Baseline varies depending on the parameter and site.
Citizen Monitoring Programs: Citizen Lake Monitoring Program - began in 1973 at the U of MN, transferred to the MPCA in 1978. Citizen Stream Monitoring Program – began in 1998.
Condition Monitoring: The baseline year is 2006, when pilot studies began for biology in streams. All of the MPCA's condition monitoring activities were fully aligned in 2009. For a given watershed, the baseline year is the year it was monitored in the original 10-year cycle (2006-2018).
Load monitoring: 2008, the year the network began operation. Complete build out of the network was completed in 2015, with 199 operational sites.
Probabilistic studies: The EPA began funding randomized studies in 2006 for streams. The first national lake study occurred in 2007.

Geographical Coverage

Both statewide and watershed scales for Citizen Monitoring Program, load monitoring, and condition monitoring data.

Data and Methodology

Methodology for Measure Calculation

EDWOM 2a) Changes in lakes over time

Annually

Citizen Monitoring Program (lakes and streams monitored by citizen volunteers)

Key parameter: Transparency
Scale: Statewide

Method: Transparency trends are calculated for each lake/stream monitored through the MPCA's Citizen Lake/Stream Monitoring Program using a seasonal Kendall test. The MPCA uses the statistical program R for all of its analyses on citizen monitoring data. Only sites with sufficient data for trend analysis will be reported in this measure. Statewide maps are created from this information, and statewide summary statistics (% of sites in this network with increasing, declining or no trend in water clarity) are manually computed. Steps to develop the annual trend maps are described in Trends-R Steps.docx and stored on the MPCA's server in this folder: X:\Agency_Files\Water\Condition Monitoring\Measures\Lakes & Streams\EDWOM2_Changes over time.

Every five years

National Lake Assessment (federally funded probabilistic lake study conducted by MPCA)

Key parameters: TP, chlorophyll-a, Secchi transparency, pesticides
Scale: Statewide/ecoregion

Method: National Lake Assessment data are queried from the National Lakes Assessment Database (permanently stored at EPA: https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys. The database is filtered for Minnesota data and data for Secchi (m), Chl-a (ug/L), TP (ug/L), Pesticide date is analyzed at the MDA Laboratory, and stored within MDA's EQuIS facility.

Due to the large number of samples and individual pesticide analytes evaluated (126 pesticide analytes in 2012), individual lake results are not be presented. Statewide detection frequencies for all pesticides detected both years are presented. Detection frequencies provide a snapshot as to whether the presence of the pesticides on a statewide level are increasing or decreasing between survey years.

Maximum concentrations are also presented to provide a sense of magnitude for the highest measured concentration. Because pesticide concentrations in lakes tend to be low relative to reference values, standards and benchmarks for the parent pesticide compounds are not presented in the graphic. Applicable water quality reference values are presented below the maximum graphic for pesticide parent compounds.

EDWOM 2b) Changes in streams over time

Annually

WPLMN long-term trends (concentration trends at large river monitoring locations)

Key parameters: total suspended solids (TSS), total phosphorus (TP), nitrite-nitrate (NO_2+NO_3)

Scale: Statewide; determined by number of stations with data minimums (20 years of data)

Methods: All samples for which no numeric value is reported due to low concentrations were given a value of exactly 0.0001 so that their value is less than any sample for which a numeric value exists, but neither greater than nor less than any other sample that was not reported due to low concentration. The typical method assigning a value that is half of the reporting limit is not acceptable for the seasonal Kendall Test because it is a rank test. Any change to the reporting limit would result in a systematic change in rank that has nothing to do with a systematic change in water quality among those samples that are below the reporting limit.

Results were not be reported for any seasonal Kendall test where the record was of insufficient length or continuity to satisfy the terms of the analysis. In cases where results met data requirements at least one parameter but not for all parameters at a given site, results were reported for the parameters with sufficient data only.

Sites for which long gaps occur were evaluated on a case-by-case basis to make sure that the period represented by the data remains comparable. For cases in which a period of consistent sampling sufficient to satisfy the requirements of the analysis follows a long gap in the record is present, data prior to the were removed. Results for datasets with large gaps that could not be dealt with in this way were excluded because they did not meet the minimum data requirements for this analysis.

Water quality records analyzed in this study were subsampled prior to analysis such that one sample per season was randomly chosen and the rest were discarded. Seasons were designated as follows; season 1 (spring) is March-May, season 2 (summer) is June-August, season 3 (autumn) is September-November, and season 4 (winter) is December-February. Subsampling was performed to create a dataset with homogenous sample frequency such that the final analysis weighs periods of high sample frequency and periods of low sample frequency equally. An additional reason for subsampling is that WPLMN sample collection protocol requires water samplers to be collect three or more samples for each flow event (rising limb, peak flow, and falling limb samples). Subsampling makes it much less likely for an individual high flow event to be over-represented in the dataset.

Analysis

The seasonal Kendall test was performed using the 'rkt' package in R. Seasons were defined as above, and hydrologic discharge was used as a covariable. Significance was defined as any result with an associated p value of <0.10. The direction of significant trends were determined by the sign of the partial score; a positive partial score indicates an increasing trend and a negative partial score indicates a decreasing trend. Results for any dataset found not to meet the minimum data requirements as defined above were not reported.

R is a widely used open source statistical package available for no charge at http://www.cran.r-project.org/

Annual

MDA Pesticide Reporting Streams and Rivers (watersheds monitored by MDA and other cooperators) – annual tracking of detection frequency and concentrations statistics.

Key parameters: acetochlor, atrazine, chlorpyrifos and metolahclor

Scale: Statewide

Methods: Annually, MDA completes statewide surface water monitoring for pesticides utilizing a tiered approach that intensifies sampling efforts at locations that have exhibited elevated pesticide concentrations. MDA monitoring focuses on the agricultural and urban areas of the State where pesticide usage tends to be greatest. Approximately 600-800 pesticide samples are collected annually from river and stream locations each year. Each sample can be analyzed for approximately 150 different pesticide compounds. The graphics presented the three pesticides identified as "Surface Water Pesticides of Concern": acetochlor, atrazine, and chlorpyrifos. Metolachlor is also presented due to its high detection frequency. Annual detection frequencies and concentrations are presented by combining data for all statewide Tier 1 and Tier 2 locations representing the agricultural areas of Minnesota. Sample collection locations are also presented.

Concentration trend graphics with the median, 75th and 90th percentile statistics are also presented for the same chemicals. The relevant surface water aquatic life standards for the individual chemicals are presented in the graphic title. Due to limited detections, all individual chlorpyrifos detections are presented. MDA includes all of these results in their Annual Water Quality Monitoring Report.

<u>Every ten years</u>

Condition Monitoring (compare results of revisits to target sites within a given watershed from visits that occurred ten years prior)

Key parameters: index of biotic integrity (fish, invertebrates)

Scale: watershed and statewide

Method: Anchor site selection is under development to track change in IBI scores at a watershed scale. These sites will have biological sampling within each watershed on a 10-year rotational basis. The first watersheds will be sampled for the second time in 2017; after that data collection, analysis will be conducted to determine if there is a statistically valid change in IBI score across a watershed. While this comparison will not provide a statistical trend at individual sites, it will reveal changes in overall biological community at a watershed scale after a 10-year period of time.

Data Source

EDWOM 2a): Citizen monitoring data, water quality data, state add-on for the national survey for lakes and pesticide data for lakes are located in the MPCA and MDA's EQuIS water quality database; lake chemistry data from national surveys is stored in the EPA's databases.

EDWOM2b): Load monitoring, water quality monitoring, and pesticide chemistry data for streams are located in the MPCA and MDA's EQuIS water quality database; flow data for load monitoring is stored in Hydstra, and biological and physical habitat data from watershed condition monitoring and probabilistic surveys are stored in the MPCA Biological Monitoring Unit program databases.

Data Collection Period

EDWOM 2a): Citizen Lake Monitoring Program sites are sampled annually May to September.

National Lake Assessment surveys: Data are collected every 5 years, starting in 2007, with the index period of June to September.

Condition monitoring: Watershed lake chemistry data are collected annually from May to September, with each major watershed sampled for a two year period every 10 years.

EDWOM 2b): Load monitoring sites are sampled annually during open water.

State Probabilistic flowing water surveys: Data are collected every 5 years, starting in 2010; index period June to August.
Condition monitoring: Watershed stream biological, chemical and physical habitat data are collected annually with an index period of May to September, with each major watershed sampled for a two year period every 10 years.

Data Collection Frequency

EDWOM 2a): Citizen monitoring: Transparency data are collected through volunteer efforts. Volunteers are encouraged to collect weekly data from May-September, but actual sampling frequency is variable. Data are submitted to EQuIS through the MPCA each fall/winter.
National Lake Assessment survey: Occurs every five years on a rotating schedule. Surveys have been completed in 2007, 2012, and 2017. Approximately fifty sites are selected randomly for each survey for national and statewide estimates, and an additional 100 sites are added to this to allow for ecoregional trend analysis. Sites are sampled once during the survey in between June and September. A certain number of sites are selected for revisits for quality assurance purposes for each survey.
Condition monitoring: Data are collected by MPCA staff and local partners. Each of Minnesota's 80 major watersheds were monitored from 2008-2018, with eight watersheds monitored on average each year. Watersheds will be revisited starting in 2017. Lakes are sampled monthly from May-September for two years.

EDWOM 2b): Load monitoring: Data are collected by MPCA staff and local partners at least monthly and during events (snowmelt and rain events) for pollutant loading. Each site is sampled between 25-35 times annually.
Stream monitoring: The MPCA sampled 30-50 sites for each of Minnesota's 11 major basins from 1996-2005. The sites were sampled from June-September using MPCA sampling methods. Fish, invertebrate, habitat, and nutrients were sampled at each of the sites with 10% duplication to ensure method consistency. Random stream surveys are completed every 5th year starting in 2010. Approximately 150 sites are selected randomly for each survey for state and ecoregional trend analysis. Monitoring is conducted June-September. A certain number of sites are selected for revisits for quality assurance purposes for each survey.
Condition monitoring: Each of Minnesota's 80 major watersheds were monitor from 2008-2018, with eight watersheds monitored on average each year. Revisits to watersheds will began in 2017. Biological data are collected by MPCA staff. Streams are generally sampled for fish/habitat in June to August, and invertebrates in the July-September timeframe. Streams are sampled for chemistry by MPCA staff or local contractors three times monthly May-September for the first year, and then twice per month June-September the second year.

Supporting Data Set

The data sets supporting the graphics shown in this measure are large and complex. In addition, substantial summarization and analyses were necessary to generate the graphics. Requests for additional information regarding the various graphics can be addressed by the contacts shown at the end of this document.

Caveats and Limitations

Statistically significant trends can be calculated on the Citizen Monitoring Program lake and stream data. The load monitoring network began operation in 2008, but can rely on historical data to detect long term trends at a subset of sites. Data from the National surveys are randomized so the results are unbiased; however, trend detection will not be possible for decades. National probabilistic surveys of lakes and streams, funded and coordinated by USEPA, are conducted every five years and show general statewide and ecoregional water quality and biology conditions. Lastly, condition monitoring occurs following a rotating watershed approach; these data will provide an opportunity (starting ~2020) to compare lake and stream assessment results from the first cycle to the second.

Most of the monitoring networks mentioned in this measure (load, condition monitoring, probabilistic studies) result in the collection data above and beyond the key parameters chosen to represent this measure. As programs develop, the key parameters for this measure may change to incorporate other parameters.

Data on pesticides in surface water is highly variable from year to year. The data often contains multiple detection limits, missing values, and unquantifiable detections. The data over time is typically non-linear, contains multiple peaks, and has inconsistent variability over time making analysis of results quite difficult. As a result data variability, graphical representations of the data will frequently suggest trends before statistical analysis confirms a trend is present.

Future Improvements

This measure will be modified to clarify the Methodology for Measure Calculation as those methods are developed and refined.

Financial Considerations

Contributing Agencies and Funding Sources

MPCA – Clean Water Fund and General Fund; USEPA for National Aquatic Surveys

Substantial funding for surface water pesticide work comes from non-clean water funds. This also includes limited funds from the EPA.

Communication Strategy

Target Audience

Local, state and federal agencies, legislators, and the general public.

Associated Messages

This measure conveys information about the trending condition of water quality in the state. Once Clean Water Funded activities have been ongoing for many years (>10 years), the water quality trend information will also convey information as to whether or not restoration and protection planning activities are succeeding.

Outreach Format

TBD.

Other Measure Connections

These measures touch on many of the other surface water-focused measures because it reflects the overall trends in water quality in lakes and streams.

Measure Points of Contact

Agency Information

EDWOM 2a):

Lake chemistry, Citizen Monitoring Programs: Pam Anderson, MPCA, Water Quality Monitoring Unit supervisor, pam.anderson@state.mn.us

Pesticide monitoring: Bill VanRyswyk, MDA, Pesticide Monitoring Unit supervisor, bill.vanryswyk@state.mn.us

EDWOM 2b):

Pollutant load monitoring: Lee Ganske, MPCA, Groundwater and Load Monitoring Unit supervisor, lee.ganske@state.mn.us

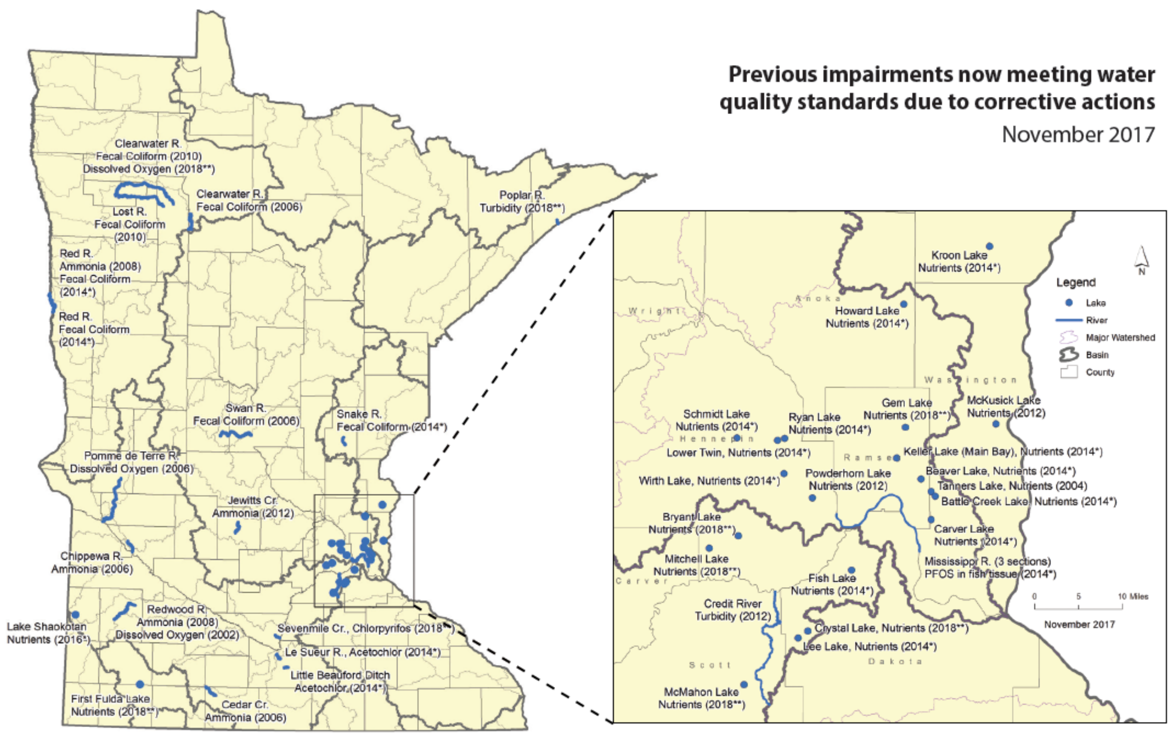
Pesticide monitoring: Bill VanRyswyk, MDA, Pesticide Monitoring Unit supervisor, bill.vanryswyk@state.mn.us

Stream biological monitoring (fish, invertebrate), stream chemistry monitoring: Scott Niemela, MPCA, North Biological Monitoring Unit supervisor, scott.niemela@state.mn.us

Number of previous impairments now meeting water-quality standards due to management actions

Measure Background

Visual Depiction



*Waters proposed for delisting in the 2014 and 2016 listing cycles are currently under review for EPA approval.
**Waters proposed for delisting in the 2018 listing cycle are subject to public comment and EPA approval.

Measure Description

The measure will identify waters restored due to a management action (best management practice installation, wastewater upgrade, etc.) taken to fix a pollution problem, rather than a delisting that's due to better monitoring data or other reasons unrelated to actual restoration activities.

Associated Terms and Phrases

- Water quality standards identify allowable concentrations (per Minnesota regulations) of specific pollutants in water, established to protect its beneficial uses such as recreation, aquatic life, drinking water, fish consumption and others.
- A lake or stream is considered impaired if monitoring data reveals that it is not meeting a water quality standard. Each state updates a list of these impaired waters is updated every two years.
- Minnesota's 2018 proposed Impaired Waters List contains 2727 impairments that require TMDL studies; 581 of those impairments are proposed new listings. The Inventory of all impaired waters now totals 5085, which includes impairments in need of TMDLs, those with completed

TMDLs that have not yet been restored, and impairments due to non-pollutants and natural sources.

- The 2018 proposed new listings requiring TMDLs are mostly impairments for: poor biological communities (63 percent of new listings), bacteria (19 percent of new listings) nutrients (9 percent of new listings), , dissolved oxygen (3 percent of new listings), sediment (3 percent of new listings), and mercury in fish tissue (2 percent of new listings)..
- The 2018 list was developed under an approach to assessment that focuses on comprehensive assessment of water quality within major watersheds. The MPCA has a 10-year schedule for monitoring and assessing each of Minnesota's 80 major watersheds.

Target

Ultimately, the goal is for all impaired waters in Minnesota to be restored. However, achieving this goal is unlikely due to lack of adequate economic resources, extremely degraded water quality in some cases, and other constraints.

Baseline

The baseline year for this measure is 2002, which is the year that the first water body was removed from the impaired waters list ("delisted") due to a management action that resulted in it again meeting water quality standards.

Geographical Coverage

This measure is statewide.

Data and Methodology

Methodology for Measure Calculation

The MPCA recommends "Delistings" (i.e., removal from the impaired waters list) to the U.S. EPA through the impaired waters list approval process. Delistings are determined according to the MPCA's assessment and delisting methodology.

Data Source

The data for the measure is maintained (see below) by the MPCA's Environmental Outcomes Division's Delisting Committee through its delisting review process.

Data Collection Period

1998 to present.

Data Collection Methodology and Frequency

Water quality monitoring data is assessed by the MPCA every two years and then documented in two places:

Supporting Data Set

As of 12/31/2017:

1. Data and decisions reached are documented in a spreadsheet maintained by the MPCA's Delisting Committee
2. Summary data listed below is also located in a spreadsheet maintained by the MPCA's regional division.

Reach	Pollutant or stressor	Year listed	Year de-listed	Comments

Bryant	Excess nutrients	2008	2018*	Actions in watershed: alum treatment and stormwater management.
Clearwater River	Low Oxygen	2002	2018*	Actions in watershed: implementation of BMPs by landowners and altered drainage practices by wild rice farmers.
Clearwater River	Low Oxygen	2002	2018*	Actions in watershed: implementation of BMPs by landowners and altered drainage practices by wild rice farmers.
Crystal	Excess nutrients	2002	2018*	Action in watershed: stormwater management, removal of invasive aquatic plants.
First Fulda	Excess nutrients	2008	2018*	Actions in watershed: stormwater management, filter strips, shoreland restoration, channel reconstruction, tile inlet upgrades, and increase conservation tillage. Drawdown due to dam replacement.
Gem	Excess nutrients	2010	2018*	Actions in watershed: stormwater improvement projects.
McMahon	Excess nutrients	2002	2018*	Actions in watershed: shoreline restoration/stabilization and curly leaf control.
Mitchell	Excess nutrients	2002	2018*	Actions in watershed: stormwater BMPs and in-lake management.
Poplar River	Turbidity	2004	2018*	Actions in watershed: near channel and upland erosion control BMPs.
Sevenmile Creek	Chlorpyrifos	2012	2018*	Actions in watershed: BMPs for chlorpyrifos use and application.
Red Rock Lake	Excess nutrients	2002	2016*	Actions in watershed: stormwater management, sediment dredging, removal of invasive aquatic plants.
Battle Creek Lake	Excess nutrients	2002	2014*	Action in watershed: implementation of stormwater treatment in watershed.
Beaver Lake	Excess nutrients	2002	2014*	Action in watershed: implementation of stormwater treatment.
Carver Lake	Excess nutrients	2008	2014*	Action in watershed: improved stormwater treatment.
Fish Lake	Excess nutrients	2006	2014*	Action in watershed: active management of alum treatment and aquatic plant harvesting.

Howard Lake	Excess nutrients	2006	2014*	Action in watershed: restoration project which included fish barriers and treatment to eliminate rough fish.
Keller Lake (main bay)	Excess nutrients	2002	2014*	Action in watershed: improved stormwater treatment.
Kroon Lake	Excess nutrients	2008	2014*	Action in watershed: feedlot retired, conversion of land use, stormwater BMPs in place.
Le Sueur River, Maple R to Blue Earth R	Acetochlor	2008	2014*	Delist based on new comprehensive data. Actions in watershed: implementation of pesticide best management practices for pesticides.
Lee Lake	Excess nutrients	2002	2014*	Action in watershed: stormwater BMPs in place, half of runoff to the lake receives some form of treatment. TMDL approved 9/30/11
Lower Twin	Excess nutrients	2002	2014*	Action in watershed: Restoration activities underway. TMDL and implementation plan approved 11/9/07 and 11/13/07.
Mississippi River, L & D #1 to Minnesota R	PFOS in fish tissue	2008	2014*	Actions in watershed: restoration activities through improvements in upstream discharges.
Mississippi River, Metro WWTP to Rock Island RR Bridge (RM 835 to 830)	PFOS in fish tissue	2008	2014*	Actions in watershed: restoration activities through improvements in upstream discharges.
Mississippi River, Minnesota R to Metro WWTP (RM 844 to 835)	PFOS in fish tissue	2008	2014*	Actions in watershed: restoration activities through improvements in upstream discharges.
Red River of the North Fargo/Moorhead Dam 1 to Dam A	Fecal coliform	1994	2014*	Actions in watershed: sewer separation and rehab, stormwater permitting and BMPs.
Red River of the North, Fargo/Moorhead Dam A to Sheyenne R (ND)	Fecal coliform	1994	2014*	Actions in watershed: sewer separation and rehab, stormwater permitting and BMPs.
Ryan Lake	Excess nutrients	2002	2014*	Action in watershed: restoration activities underway per TMDL Implementation Plan. TMDL approved 11/9/07.
Schmidt Lake	Excess nutrients	2002	2014*	Action in watershed: restoration activities underway per TMDL Implementation Plan. TMDL approved 09/25/09.
Snake River, Knife R to Fish Lk outlet	Fecal coliform	2008	2014*	Action in watershed: targeted installation of BMPs and for animal operations.

Unnamed creek (Little Beauford Ditch), Headwaters to Cobb R	Acetochlor	2008	2014*	Delist based on new comprehensive data. Actions in watershed: implementation of pesticide best management practices for pesticides.
Wirth Lake	Excess nutrients	2002	2014*	Action in watershed: structure to prevent backflow from Bassett Creek which was primary source of phosphorus to the lake.
Credit River, Headwaters to Minnesota R	Turbidity	2002	2012	Action in watershed: construction erosion control programs, various projects including bank and channel stabilization, and rain gardens.
Jewitts Creek, Headwaters (Lk Ripley) to N Fk Crow R	Ammonia (un-ionized)	1994	2012	Action in watershed: construction of upgraded wastewater treatment facility for Litchfield.
McKusick Lake	Excess nutrients	2006	2012	Action in watershed: various watershed district projects to reduce runoff to the lake
Powderhorn Lake	Excess nutrients	2002	2012	Application of in-lake management techniques resulted in improved water quality
Clearwater River, Ruffy Bk to Lost R	Fecal Coliform	2002	2010	Action in watershed: Implementation of BMPs by landowners and altered drainage practices by wild rice farmers.
Lost River, Anderson Lk to Hill R	Fecal Coliform	2002	2010	Action in watershed: construction of wastewater treatment facility for Oklee and implementation of BMPs by landowners.
Red River of the North, Fargo/Moorhead Dam A to Sheyenne R (ND)	Ammonia (un-ionized)	1992	2008	Site specific water quality standard since 2000. Delist based on new monitoring data. Actions in watershed: improvements to Fargo (1995) and Moorhead (2003) wastewater treatment facilities.
Redwood River, T111 R42W S33 west line to Threemile Cr	Ammonia (un-ionized)	1992	2008	Delist based on new monitoring data. Action in watershed: upgrade of Marshall wastewater treatment facility (1994)
Cedar Creek, T104 R33W S6 west line to Cedar Lk	Ammonia (un-ionized)	1994	2006	Delist based on new monitoring data. Action in watershed: Individual Sewage Treatment System (ISTS) upgrades and feedlot inspections and manure management plans
Chippewa River, Watson Sag Diversion to Minnesota R	Ammonia (un-ionized)	1994	2006	Delist based on new monitoring data. Action in watershed: upgrade of Montevideo wastewater facility (1994)
Clearwater River, Trout stream portion	Fecal coliform	2002	2006	Delist based on new more comprehensive data. Action in watershed: upgrade of Bagley wastewater treatment facility and feedlot management practices.

Pomme de Terre River, Muddy Cr to Minnesota R (Marsh Lk Dam)	Low Oxygen	1994	2006	Delist based on new monitoring data. Action in watershed: removal of dam at Appleton
Swan River, Headwaters (Big Swan Lk, 77-0023) to Mississippi R	Fecal coliform	1994	2006	Delist based on new, more comprehensive data. Action in watershed: feedlot upgrade, feedlot inspections, BMPs.
Tanners Lake	Excess nutrients	2002	2004	Delist based on new monitoring data. Action in watershed: improvements to sedimentation ponds and facility built to treat stormwater with alum
Redwood River, Below trout stream portion to Threemile Cr	Low Oxygen	1992	2002	Delist based on new monitoring data. Action in watershed: upgrade of Marshall wastewater treatment facility (1994)

** Proposed during the 2014, 2016, and 2018 listing cycles. Currently under review for EPA approval.*

All delisting proposals are subject to public comment and EPA approval.

Caveats and Limitations

Implementation actions may be funded from a variety of state, local or federal sources so it is difficult to attribute a restoration to a single funding source such as the Clean Water Fund.

Future Improvements

No future improvements are anticipated at this time.

Financial Considerations

Contributing Agencies and Funding Sources

Not applicable

Communication Strategy

Target Audience

All audiences

Associated Messages

This measure is important to convey because it is the achievement of one of our most important environmental goals – the restoration of impaired waters due to implementation activities often led by local government and supported by local, state and federal funding.

Outreach Format

This measure will be included on the MPCA web page and linked to other state sites.

Other Measure Connections

Depending on the cause of the impairment and the activities required for restoration, other measure connections will vary widely. In general, measures related to monitoring, funding and point/nonpoint source implementation activities will be most relevant.

Measure Points of Contact

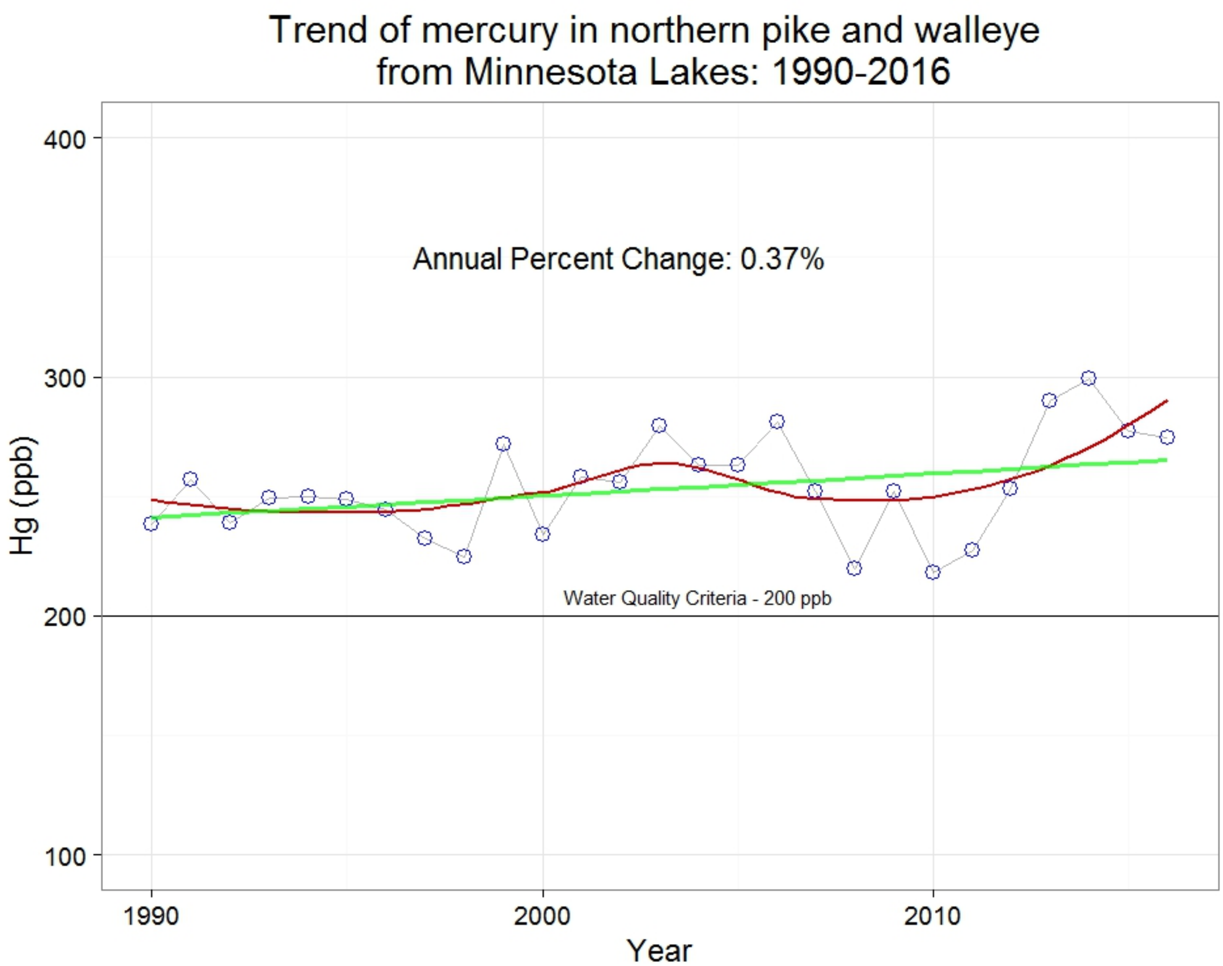
Agency Information

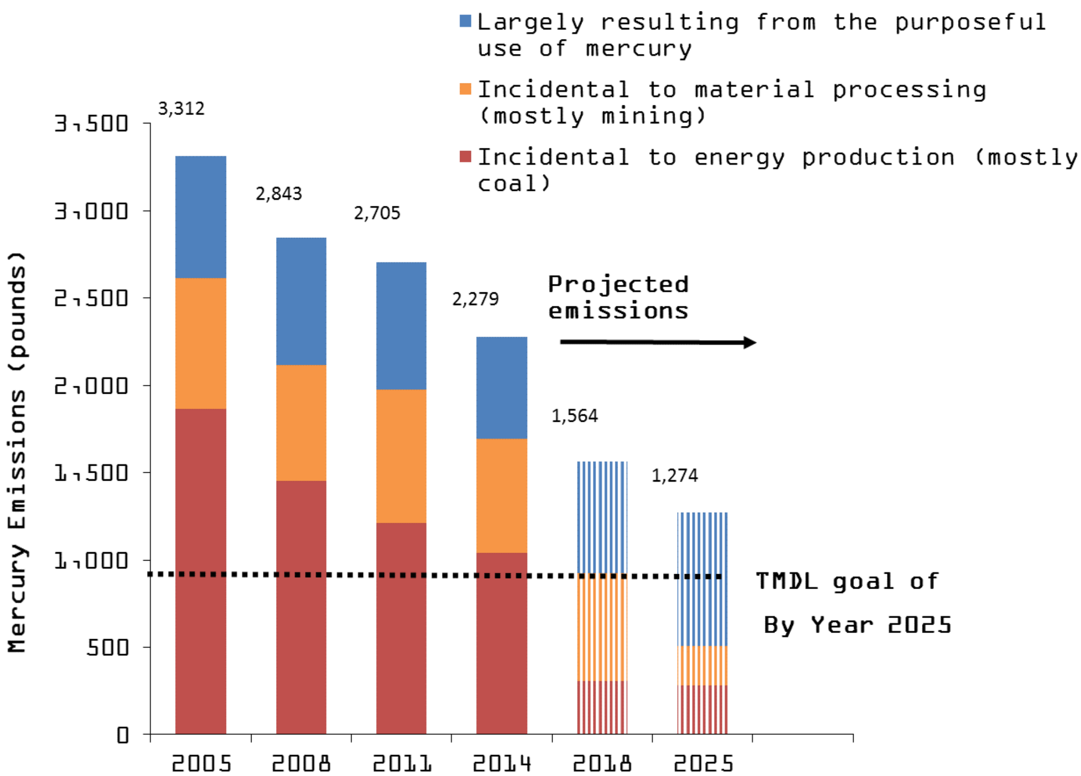
David Miller, Minnesota Pollution Control Agency
(651) 757-2448
David.L.Miller@state.mn.us

Trends of mercury in fish and Minnesota mercury emissions

Measure Background

Visual Depiction





Measure Description

Many Minnesota lakes and rivers contain mercury. Mercury bioaccumulates in aquatic food chains and may pose a risk to humans, as well as wildlife, that eat fish from those waters. Because air pollution is the primary source of mercury, reducing mercury in fish likely requires large reductions in mercury emissions from sources in Minnesota and throughout the world. To evaluate if Minnesota waters are getting cleaner, we can track Minnesota mercury emission levels over time through periodic emissions inventories and measure how fish mercury levels respond. Because of the large variation in mercury concentrations from year to year within and among lakes/rivers, long-term trends of mercury in fish are necessary to see if pollution control efforts are sufficient.

Associated Terms and Phrases

Bioaccumulates: Increased concentration of a substance in an organism with time. Bioaccumulation will occur in an organism when the rate of the substance intake is faster than the rate at which the organism is able to eliminate it. The concept of bioaccumulation is often used in reference to the concentrating of toxic substances such as pesticides, heavy metals, or certain other industrial chemicals in living organisms where bioaccumulation increases the risk of toxicity for organisms at the top of food chains.
Food chains: A relationship between the organisms in a particular ecological community whereby organisms at each trophic level (i.e., each step in the food chain) are consumed by organisms of a higher trophic level.
Mercury Emissions: The primary source of mercury pollution is from atmospheric deposition. Human sources contributed 60-70% of the atmospheric mercury and the other third is from natural sources.

Energy production—primarily burning of coal—contributes about 50% of the human-sourced mercury. The other 50% is from volatilization of mercury in products, mining operations, and other manufacturing operations that release mercury during the processing of raw materials. Mercury emitted into the atmosphere can become a global pollutant, which is why mercury deposition and fish mercury concentrations have not declined despite large reductions in North American mercury emissions from human sources.

Methylmercury: Organically bound form of mercury – as opposed to ionic or reduced free-metal state. The Minnesota fish contaminants program tests for total mercury, which includes methyl, ionic, and free-metal forms. In practice, this is nearly the same as testing specifically for methyl mercury, as over 90% of mercury contained in fish muscle tissue has been shown to be in the methyl mercury form.

Statewide Mercury TMDL: When a waterway is impaired (i.e., exceeding a water quality standard) a total maximum daily load (TMDL) is prepared, which identifies the pollutant sources and the load reduction required to meet the water quality standard. Because the primary source of mercury to waterways in Minnesota is atmospheric deposition, which is fairly uniform throughout the state, a statewide TMDL was prepared for mercury. The EPA approved the TMDL in 2007 which sets mercury reduction targets that Minnesota is currently working to achieve.

Target

The mercury emissions target for Minnesota, established in the Statewide Mercury TMDL, is 789 pounds of mercury per year. The Statewide Mercury TMDL Plan sets out strategies and a timeline to achieve this goal by 2025.

The target for mercury in fish concentrations is for all fish to have mercury concentrations below 0.2 parts per million, which is the state water quality standard for mercury in fish. Mercury in fish is expected to decrease as mercury deposition is decreased, although the lag time between source reduction and reductions in the fish is unknown. Because Minnesota receives 90% of its mercury pollution from outside the state, achieving a decline will likely require reducing pollution from both in-state and out-of-state sources. Other factors, such as the presence of wetlands, land-use practices, and climate, also influence the amount of mercury pollution that is converted to methylmercury and accumulates in aquatic food chains. As more is learned about how these factors alter how much mercury accumulates (bioaccumulates) in fish, the target for mercury in fish concentrations may need to be revised.

Baseline

The Minnesota mercury emissions inventory uses 2005 as the baseline year; the mercury in fish trend analysis had previously used 1982 as the baseline year. With the 2018 update, 1990 was used as a baseline year, which corresponds to the baseline for reduction goals in the Statewide Mercury TMDL. Beginning in 1990, fish collections were generally well-distributed throughout the state, whereas prior to 1990, sampling was focused on northern Minnesota waters because they were known to have the highest mercury concentrations.

Geographical Coverage

Minnesota has adopted a statewide strategy to address mercury pollution, outlined in the Statewide Mercury TMDL; Minnesota emissions inventory data and fish mercury levels are reported on a statewide basis to match the framework of the strategy.

Data and Methodology

Methodology for Measure Calculation

The trends of mercury in fish rely on northern pike and walleye as the indicator fish species. Because mercury concentrations increase with the age and size of a fish, the two species are standardized to specific total length (55 cm for northern pike and 40 cm for walleye). Consequently, each lake or river with one or both of these species will have a standardized length fish mercury concentration assigned to it and that value is used in the trend analysis. The length standardization methodology is described in a 2009 paper authored by B. A. Monson, Trend Reversal of Mercury Concentrations in Piscivorous Fish from Minnesota Lakes: 1982-2006, published in Environmental Science & Technology, vol. 43, pp. 1750-1755. In addition, average mercury concentrations in the fish increase with latitude (i.e., from south to north) and most of the lakes sampled in the 1980s were in the northern region of the state; therefore, the annual means of standardized length fish-mercury concentrations were also corrected for latitude and represent the mean latitude in the state.

Data Source

The DNR, Division of Ecological and Water Resources, maintains the primary fish contaminant database (ALLFISHM1.mdb). The Minnesota Department of Agriculture (MDA) currently provides the fish mercury analytical services and maintains the associated analytical and quality assurance records.
Mercury emissions in Minnesota are inventoried at least every five years by the MPCA. The emissions estimates for each source are either measured directly or calculated. As measurement technology improves, more of the emissions are being measured rather than calculated.

Data Collection Period

Fish contaminant data have been collected from 1967 to the present year. Data were collected in all years, although the number of samples varied from year to year.
Minnesota's mercury emissions have been estimated every five years since 1990.

Data Collection Methodology and Frequency

The DNR, Division of Ecological and Water Resources, maintains a methods document that outlines the procedures used to collect, store, and process fish for mercury tissue analysis.
The data for mercury emissions is either measured directly or calculated. Direct measurements are increasingly done by the emissions sources, such as coal-fired power plants. Emission calculations follow a procedure developed by the U.S. EPA. The calculations are essentially the mercury concentration per unit of production multiplied by the total production volume.

Supporting Data Set

The fish-mercury trend uses standardized lengths to normalize the mercury concentrations: 55 cm for Northern pike and 40 cm for Walleye. The tabular data is available on request from Bruce Monson, MPCA.
The mercury emissions inventory is available at https://www.pca.state.mn.us/sites/default/files/wq-iw4-02f6.pdf.

Caveats and Limitations

Caveats and limitations associated with the sample collection and sample processing are outlined in the methods document maintained by the DNR, Division of Ecological and Water Resources.
The standardized length fish mercury concentration is based on the available northern pike and walleye collected from each lake. The relationship between mercury concentration and fish length can vary from year to year within a lake, as well as among lakes and rivers. Consequently, each standardized mercury concentration has some uncertainty (i.e., confidence interval) associated with it, but that uncertainty is not explicitly included in the trend analysis; assumptions are made that the uncertainty fits within a normal distribution.

For the mercury emissions inventory, there is uncertainty in measured values and in the calculated emissions. The confidence in the calculations is qualitatively assessed based on the quality of the information available to make the calculations. For example, there is high confidence in the mercury emissions from coal-fired power plants, but very low confidence in the mercury emissions from solid waste collection and processing.

Future Improvements

As mentioned above, more mercury emissions are being measured, which will improve the confidence in those estimates. Calculations of standardized length fish mercury concentrations are not expected to change; however, new statistical methods may be applied to the trend analysis if they provide improved inference about the changes in mercury concentrations.

Financial Considerations

Contributing Agencies and Funding Sources

Not applicable

Communication Strategy

Target Audience

In addition to businesses and organizations in Minnesota whose air emissions of mercury are covered by the Statewide Mercury TMDL Plan, Minnesota residents and visitors who consume fish caught from Minnesota waters and individuals interested in the health of Minnesota's fish-eating wildlife will be particularly interested in this measure.

Associated Messages

The measure directly links efforts to reduce the release of an air pollutant, mercury, and a specific environmental outcome, reducing mercury in fish. It helps show whether a specific pollution-reduction effort is having the desired environmental affect. In addition, because Minnesota receives 90% of its mercury pollution from outside of the state, the measure also shows the extent to which in-state reductions in mercury air emissions are sufficient.

Outreach Format

In addition to help conveying success in meeting Clean Water goals, this measure will complement MPCA's current effort to provide information to those businesses with air emissions permits for mercury or businesses whose air emissions of mercury may be regulated in the future, as well as organizations/individuals interested in air emissions permitting.

Other Measure Connections

Not applicable

Measure Points of Contact

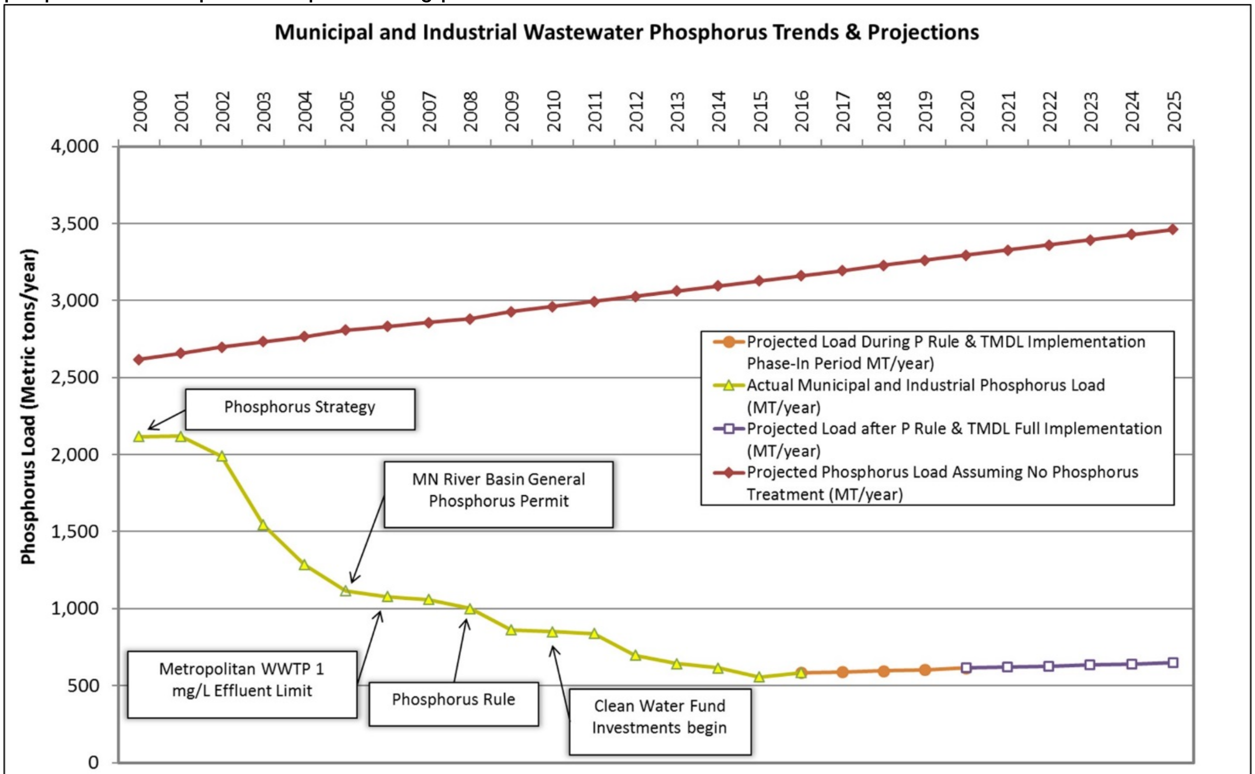
- David Wright, Minnesota Department of Natural Resources, David.I.Wright@state.mn.us
- Paul Hoff, Minnesota Pollution Control Agency, paul.hoff@state.mn.us
- Frank Kohlasch, Minnesota Pollution Control Agency, frank.kohlasch@state.mn.us

Changes over time in municipal wastewater phosphorus discharges

Measure Background

Visual Depiction

This graph represents statewide municipal wastewater treatment facility phosphorus reductions since the year 2000, projects future reductions based on the implementation of current permitting policies, and contrasts them to anticipated increases in phosphorus loading that would have resulted from the perpetuation of previous permitting policies.



Estimated statewide reductions in phosphorus from municipal wastewater treatment facilities since the year 2000 and projections of future reductions based on current permitting policies, implementation of Total Maximum Daily Load (TMDL) requirements , and Clean Water Fund Investments.

Measure Description

The measurements are statewide municipal wastewater treatment facility phosphorus trends and projections assuming a 1% per year population growth rate.

- The **red line** displays the estimated phosphorus loading if no reductions had been made and effluent phosphorus concentrations remained at 4 mg/L. The projected increase in loading assumes a linear relation between population growth and water usage.
- The **yellow line** represents DMR data reported for since the year 2000.

- The **orange line** represents a phase-in period for the full implementation of phosphorus reductions required by existing water quality standards.
- The **purple line** represents the loading expected with the full implementation of the P rule and incorporates a potential 1% annual increase in loading as facilities increase flow to meet future demands.
- Actual wastewater loads are based on discharge monitoring report data. TMDL implementation, river eutrophication standards and operational margins of safety are expected to reduce future phosphorus loads beyond projected values.

Associated Terms and Phrases

The Phosphorus Strategy was a permitting approach adopted by the MPCA in 2000. It established policies to assign 1 mg/L effluent phosphorus permit limits for municipal wastewater treatment facilities that had the potential to discharge annual phosphorus loads in excess of 1,800 lbs/year to specific watersheds and waterbodies. Municipal wastewater treatment facilities that were not assigned effluent phosphorus limits were required to monitor influent and effluent phosphorus and develop phosphorus management plans.

The Minnesota River Basin General Phosphorus permit was issued in 2005 to implement the wasteload allocations established by the Lower Minnesota River Dissolved Oxygen TMDL. It established baseline load and pollutant load reduction requirements for the 39 largest continuously discharging municipal and industrial wastewater dischargers in the 8 major watersheds of the Minnesota River basin.

The Metropolitan WWTP is the largest wastewater treatment facility in Minnesota with an average annual design flow or 251 mgd.

The "phosphorus rule" refers to the 2008 modifications to Minnesota Rules Chapter 7053.0255. It codifies the phosphorus strategy but extends its requirements to all Minnesota watersheds.

Target

The Projected P Rule (MT/year) target of 619 MT/year is estimated as a result of applying the categorical performance goals developed for the draft Lake Pepin TMDL to all municipal wastewater treatment facilities.

Baseline

Baseline year: 2000

Baseline load: 1,902 metric tons/year

Geographical Coverage

Statewide

Data and Methodology

Methodology for Measure Calculation

The projections are based on a **1 % per year population** growth estimate.

All municipal ("city") populations are used to calculate municipal flow. All rural ("township") populations are assumed to be outside municipal service boundaries.

92% of the flow and load are assumed to be from cities with populations greater than 2000.

TMDL implementation, river eutrophication standards and operational margins of safety are expected to reduce future wastewater loads below the projections.

The year 2000 discrepancy between "Actual Municipal Phosphorus Load" and "Projected Phosphorus Load Assuming Non Phosphorus Treatment" reflects pre-2000 implementation of phosphorus effluent limits.

Data Source

WQ Delta and Tempo databases of discharge monitoring report data
State demographic center population estimates

Data Collection Period

2000 - 2016

Data Collection Methodology and Frequency

Actual Municipal Phosphorus Load data (yellow line) will be updated annually from discharge monitoring report data.

Supporting Data Set

	Domestic								*Original Graph from 'PhosGraph_DOMvsIND.xlsx' in Old Folder
	Flow (MG/y)	Conc. (mg/L)	TP Load (MT/y)	Project TP Load @ 2000 Conc (MT/y)	No of Permits		No. of Permits with P Limits		
2000	178,106	3.42	2,305	2,305	511		80		
2005	210,756	2.49	1,985	2,727	552		100		
2009	160,932	2.41	1,471	2,082	573		119		

Average Municipla Wastewater Flow/Capita = 0.0406 MG/capita/year
Average Municipla Wastewater Flow/Capita = 111 gal/capita/day

									Municipal		
Year	Population within Municipal Boundaries	Projected Average Municipal Wastewater Flow (MG/y)	Projected Phosphorus Load Assuming No Phosphorus Treatment (MT/year)	Actual Municipal Wastewater Flow (MG/y)	Actual Industrial Wastewater Flow (MG/y)	Estimated Municipal Phosphorus Load (MT/year)	Municipal Phosphorus Load (MT/year)	Industrial Phosphorus Load (MT/year)	Actual Municipal and Industrial Phosphorus Load (MT/year)	Projected P Rule & TMDL Implementation Phase-In Period MT/year)	Projected P Rule & TMDL Full Implementation (MT/year)
2000	4,257,328	172,848	2,617	179,658	101,645	2,305	1,902	214	2,116		
2001	4,324,100	175,558	2,658	199,191	99,609		1,923	196	2,119		
2002	4,387,230	178,122	2,697	203,696	101,056		1,813	177	1,990		
2003	4,444,786	180,458	2,732	173,074	94,871		1,379	163	1,542		
2004	4,500,777	182,732	2,767	183,658	102,663		1,123	162	1,285		
2005	4,567,652	185,447	2,808	171,294	117,671	926	926	187	1,114		
2006	4,607,356	187,059	2,832	169,915	123,735		896	182	1,079		
2007	4,648,222	188,718	2,857	170,913	124,637		873	185	1,058		
2008	4,686,816	190,285	2,881	167,767	131,044		817	184	1,000		
2009	4,762,705	193,366	2,928	158,624	127,976		676	186	862		
2010	4,816,929	195,567	2,961	171,025	121,843		657	194	851		
2011	4,871,153	197,769	2,994	180,379	123,424		659	180	839		
2012	4,925,377	199,970	3,028	151,049	116,701		546	152	698		
2013	4,979,601	202,172	3,061	162,440	139,045		532	111	643		
2014	5,033,825	204,373	3,094	173,315	114,534		528	87	614		
2015	5,088,048	206,575	3,128	158,886	107,347		471	85	556	471	
2016	5,142,272	208,776	3,161	176,024	111,987		489	95	584	466	
2017	5,196,496	210,978	3,194							461	
2018	5,250,720	213,179	3,228							457	
2019	5,304,944	215,381	3,261							452	
2020	5,359,168	217,582	3,294							447	447
2021	5,413,392	219,784	3,328								452
2022	5,467,616	221,985	3,361								456
2023	5,521,840	224,187	3,394								461
2024	5,576,064	226,388	3,428								465
2025	5,630,288	228,590	3,461								470

Caveats and Limitations

The projections are based on a **1 % per year loading increase** estimate.
All municipal ("city") populations are used to calculate municipal flow. All rural ("township") populations are assumed to be outside municipal service boundaries.
92% of the flow and load are assumed to be from cities with populations ≥ 2000.

TMDL implementation, river eutrophication standards and operational margins of safety push actual future loads below the projections.
Projected P Rule & TMDL Implementation Phase-In Period assumes a 10-year period (from 2010) to achieve full implementation.
The year 2000 discrepancy between "Actual Municipal Phosphorus Load" and "Projected Phosphorus Load Assuming Non Phosphorus Treatment" reflects pre-2000 implementation of phosphorus effluent limits.
These represent only municipal wastewater treatment facility phosphorus loads. Industrial loads are excluded because Clean Water Legacy Funds are not available for industrial wastewater improvements.

Future Improvements

TBD

Financial Considerations

Contributing Agencies and Funding Sources

None.

Communication Strategy

Target Audience

Concerned citizens, Clean Water Council

Associated Messages

None at this time.

Outreach Format

TBD.

Other Measure Connections

Related to the measure "Number of municipal point source construction projects implemented with Clean Water Funding and estimated pollutant load reductions."

Measure Points of Contact

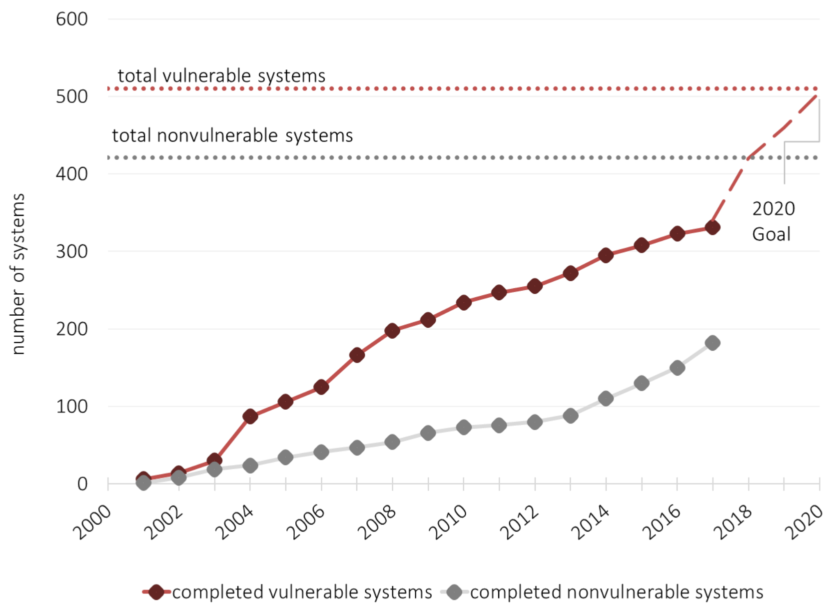
Agency Information

Marco Graziani (marco.graziani@state.mn.us), 651-757-2398
Casey Scott (casey.scott@state.mn.us), 507-206-2652

Number of community water supplies assisted with developing source water protection plans

Measure Background

Visual Depiction



Measure Description

Community public water supply systems that get their drinking water from groundwater are required to develop and implement wellhead protection plans. Wellhead protection plans entail designating a drinking water supply management area (the entire recharge area for the well), writing a wellhead protection plan, and implementing activities to protect the source water. This measure reports on plan completions based on vulnerability status because vulnerable systems have a greater need for protection from a public health perspective. Vulnerable systems are at an elevated risk for source water contamination based on well and aquifer characteristics.

Note: Source water protection plans are also developed and implemented for public water systems that get their drinking water from surface water supplies, but are not included in this measure as they are a voluntary effort.

Associated Terms and Phrases

Public water system: provides water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year

Community public water system: provides water to 25 persons or 15 service connections year-round, which includes municipalities, manufactured mobile home parks, etc.

Vulnerable: at an elevated risk for source water contamination based on well and aquifer characteristics

Target
Every vulnerable community public water system is engaged in source water protection by 2020

Baseline
Data from 2001 through June 30, 2009 provides a context for this measure

Geographical Coverage
Statewide.

Data and Methodology

Methodology for Measure Calculation
The measure includes cumulative totals of community public water systems that are engaged in the wellhead protection planning process each year. A system is engaged when a scoping meeting is held with the public water system. Systems are only included in the cumulative total if they have an active status. The systems are separated by vulnerability status, which is determined by rules specified under Minnesota Rules, part 4720.5210. Any system classified in the data as low, medium, high, or very high vulnerability is considered vulnerable for the purposes of this report.

Data Source
Two internal Minnesota Department of Health (MDH) databases (Source Water Protection Tracker and Minnesota Drinking Water Information System)

Data Collection Period
Fiscal Years 1998 to 2017

Data Collection Methodology and Frequency
MDH staff input and update information on an ongoing basis

Supporting Data Set
County Geologic Atlases and County Well Index

Caveats and Limitations
The total number of community public water systems may vary by year, depending on systems becoming inactive or new systems becoming active. In 2015, the U.S. Environmental Protection Agency (EPA) changed source water reporting for systems that purchase water from another system. Previously the systems were counted as one, but now they are counted separately. Therefore, if a system providing water has a source water protection plan, each system purchasing water is counted as having source water protection plans.

The vulnerability status of a system may also change yearly based on a variety of factors such as drilling a new supply well. This change would be reflected in the cumulative totals.

Minnesota Rule requirements on wellhead protection require plans to be amended after 10 years. These required amendments create a workload that can displace new plan development work.

Future Improvements
The Source Water Protection Tracker database is undergoing major updates to improve the capability to manage plan development and implementation activities.

Financial Considerations

Contributing Agencies and Funding Sources

The EPA provides baseline funding for the source water protection program in Minnesota. The Clean Water, Land and Legacy Amendment appropriation supports part of the planning and technical assistance activities for wellhead protection, allowing more public water systems to be brought into the planning process than would otherwise be possible.

Communication Strategy

Target Audience

Public water supply systems

Associated messages

1. Source water protection activities help to prevent contaminants from entering a public water supply at levels that could negatively affect human health.
2. The goal is to engage all vulnerable community public water supply systems in wellhead protection planning efforts by 2020.

Outreach Format

MDH assists public water suppliers in developing and implementing wellhead protection plans. A number of partnerships are leveraged in this effort.

Other Measure Connections

Number of grants awarded for source water protection

Measure Points of Contact

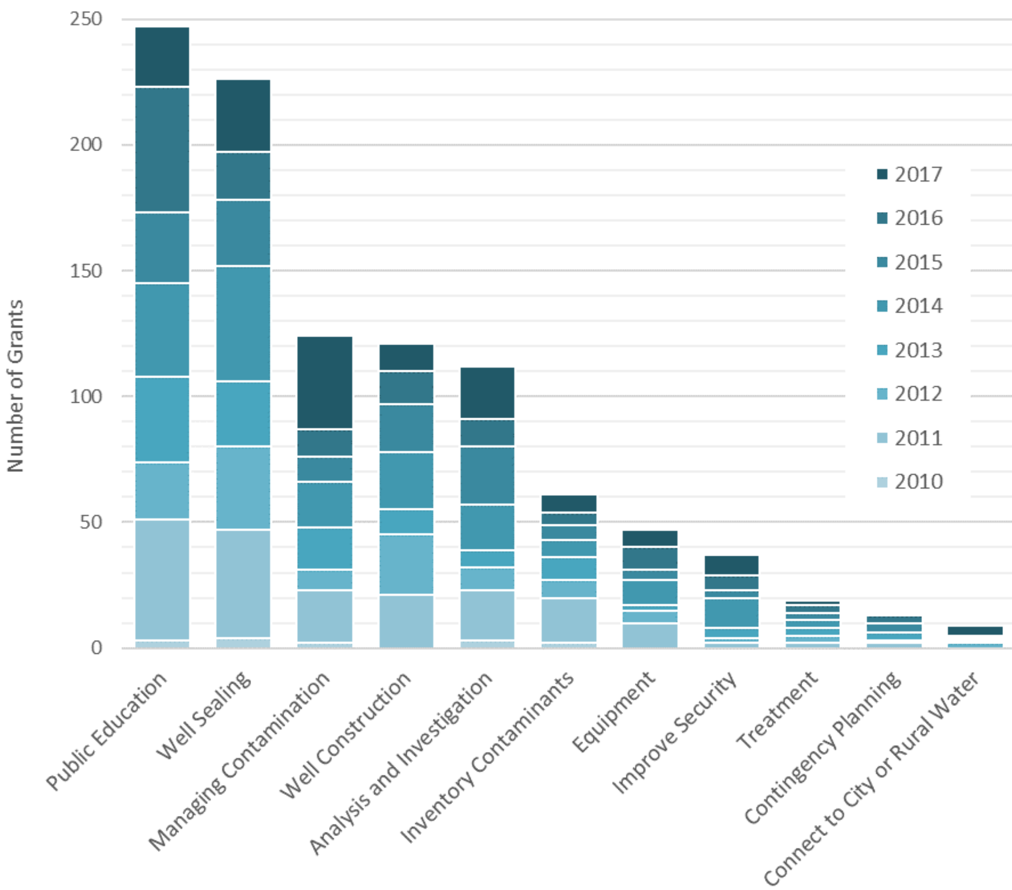
Lead Agency Information

Stephen W. Robertson, steve.robertson@state.mn.us

Number of grants awarded for source water protection

Measure Background

Visual Depiction



Measure Description

Grants help public water suppliers implement activities to protect the sources of drinking water. Three types of source water protection (SWP) grants are available to public water suppliers and applications open twice a year.

1. *SWP Implementation Grants* (no cost share required): fund activities included in source water protection plans for community and noncommunity systems.
2. *SWP Competitive Grants* (50/50 cost share required): fund applicable activities that are not included in source water protection plans for community and noncommunity systems.
3. *SWP Transient Grants* (50-50 cost share required): fund applicable activities for transient public water supply systems. Source water protection plans are not developed for transient systems.

Associated Terms and Phrases

Public water supply system: provides water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year.
Community public water supply system: provides water to 25 persons or 15 service connections year-round, which includes municipalities, manufactured mobile home parks, etc.
Noncommunity public water supply system: provides water to the public in places other than their homes—where people work, gather and play.
Transient public water supply system: facilities that serve at least 25 people at least 60 days of the year, but do not serve the same 25 people over six months of the year.

Target

The target is to increase the number grants for source water protection activities each year.

Baseline

There was no grant assistance for public water systems prior to the Clean Water Fund.

Geographical Coverage

Statewide.

Data and Methodology

Methodology for Measure Calculation

MDH categorizes grants into the following source water protection activity groupings: well sealing, well construction, analysis and investigation, managing contamination, equipment, public education, improve security, contaminant source inventory, contingency planning, treatment, and connecting to city or rural water. The amount awarded, not actual dollar amount spent, is reported in the measure. The number of grants refer to the number of activities rather than the number of public water suppliers funded. A grant received by a public water supplier for well sealing and public education would be counted twice and the corresponding funds would be assigned to each activity.

Data Source

An internal Minnesota Department of Health (MDH) database ("SWP Grants Database")

Data Collection Period

Fiscal Years 2010-2017

Data Collection Methodology and Frequency

MDH staff input and update information on an ongoing basis. Final accounting occurs at the end of each fiscal year.

Supporting Data Set

MDH uses two internal databases (Source Water Protection Tracker and Minnesota Drinking Water Information System) to populate supporting information in the SWP Grants database.

Caveats and Limitations

N/A

Future Improvements

Financial Considerations

Contributing Agencies and Funding Sources

The U.S. Environmental Protection Agency provides funding for MDH to develop protection plans and provide technical assistance for public water supply systems. The Clean Water, Land and Legacy Amendment appropriation provides funding for grants.

Communication Strategy

Target Audience

Public water supply systems

Associated Messages

1. Source water protection activities help to prevent contaminants from entering a public water supply at levels that could negatively affect human health.
2. The goal is to engage all community public water supplies in wellhead protection planning efforts by 2020.
3. SWP Grants not only enable implementation activities, but also leverage resources from other funding sources.
4. The public water system demand for financial assistance for source water protection activities typically exceeds available funding.

Other Measure Connections

Number of public water systems assisted with developing and implementing source water protection plans

Outreach Format

MDH posts regular announcements of grant opportunities on the website and sends emails to public water suppliers. MDH staff leverage personal relationships and partnerships to promote grant opportunities.

Measure Points of Contact

Agency Information

Stephen W. Robertson, steve.robertson@state.mn.us

Number of local government partners participating in Clean Water funded groundwater nitrate monitoring and reduction activities

Measure Background

Nitrate is a water soluble molecule that is made up of nitrogen and oxygen. It is naturally occurring in the environment; however at elevated levels it can have negative effects on human health. Nitrate is one of most common contaminants in Minnesota's groundwater and may exceed the drinking water standard in vulnerable or sensitive aquifers. There is significant local variability in nitrate monitoring results; some areas of the state have shown little change while other areas have shown increasing nitrate trends. The most vulnerable areas of the state are the Central Sands region of central Minnesota and the Karst region located in southeast Minnesota.

Groundwater funding from Minnesota's Clean Water Fund is being used for activities that help identify potential sources of nitrate contamination and evaluate and implement practices to reduce nitrate in groundwater. The Minnesota Department of Agriculture (MDA) leads many projects and activities to protect groundwater in regions of the state most vulnerable or sensitive to contamination. There are several MDA activities currently underway. For this measure the MDA counts the number of partners that support projects related to this work.

- Rosholt Farm: A public-private partnership to improve nitrogen fertilizer efficiency and protect groundwater
- Dakota county: Validating nitrogen recommendations and water quality impacts under irrigated agriculture
- Irrigators Workshops and Adaptive Management Program in Central Minnesota
- Central Sands Private Drinking Water Well Monitoring Network
- Township Testing Program: assessment of nitrate concentrations in private wells in vulnerable townships
- Implementation of the Nitrogen Fertilizer Management Plan
- Manure testing, soil testing and aerial imagery
- Research projects focusing on nitrate reduction activities

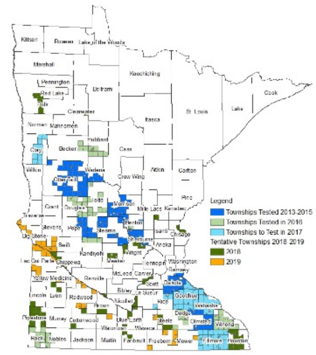
All activities reported in this measure are supported by the Clean Water Fund, in the category of Groundwater and Drinking water Protection. Many Clean Water funded projects (listed above) started in 2010-2011 and will continue until 2018 or later. New projects will depend upon results from existing projects as well as future CWF appropriations.

In 2013, the MDA completed a revision of the Nitrogen Fertilizer Management Plan (NFMP). The NFMP is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. The Plan emphasized involving local farmers and communities in problem-solving for local groundwater concerns when nitrate from fertilizer is a key contributor. The Plan includes both voluntary, and if necessary, regulatory components.

The intent of the Nitrogen Fertilizer Management Plan is to prevent, evaluate and mitigate nonpoint source pollution from nitrogen fertilizer in groundwater. The Plan includes components promoting prevention and developing appropriate responses to the detection of nitrogen fertilizer in groundwater. The strategies in the NFMP are based on voluntary BMPs and are intended to engage local communities in protecting groundwater from nitrate contamination. Implementing the Plan will result in a number of new local government partners participating in monitoring and reduction activities.

The first step in addressing nitrate in groundwater is to determine the areas of greatest concern. Areas of concern will be identified using water monitoring data from private and city wells. More than 70,000 private well owners will be offered nitrate testing in over 300 townships (35 to 59 townships per summer) by 2019. This work will be done in partnership with local governments across the state.

Visual Depiction



Visual depictions will vary depending on the specific activity or project being explained.
For example, the following map will be used to show the schedule of nitrate testing for prioritized townships. A similar format is also used to display nitrate results.
Tables, graphs and charts will be used to present results for the projects. Other visuals may include: pictures of local partners (in the field and hosting events) and short "success stories" written for newsletters or sent out as postcards.

Measure Description

This measure counts the number of local government partners participating in Clean Water funded nitrate monitoring and reduction activities. In general, local partners include Soil and Water Conservation Districts (SWCDs), Counties, and Watershed Districts. If the same partner works on multiple projects with the MDA, the partner is only counted once.

Associated Terms and Phrases

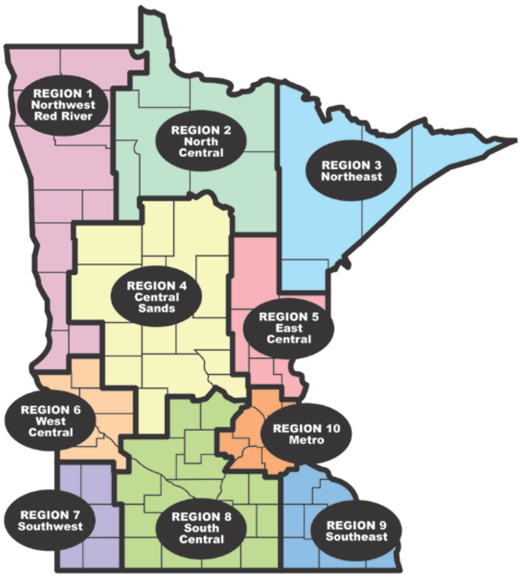
Best Management Practices: Best management practices (BMPs) are practices that are capable of protecting the environment while considering economic factors, availability, technical feasibility, ability to implement, and effectiveness. This measure refers to Nitrogen Fertilizer BMPs.

Central Sands: A region in central Minnesota that is characterized by course-textured sandy soils, often referred to as glacial outwash. There are 14 counties located in this region.
Nitrate: Nitrate (NO_3^-) is a water soluble molecule that is made up of nitrogen and oxygen. It is naturally occurring in the environment and can be taken up and used by plants. Nitrate is a negatively charged ion and does not adhere to soil particles. As a result, it can be leached and easily lost from the soil profile. Although nitrate occurs naturally, it can also come from man-made sources such as human waste, animal manure and commercial fertilizer.

Target

MDA's goal is to continue to develop effective partnerships with counties. There is no specific numeric target for this measure.
Township Testing Program: According to the recently revised Nitrogen Fertilizer Management Plan, the MDA plans to analyze water samples from approximately 70,000 private wells, in about 250-300 vulnerable townships, between 2014 and 2020. In townships with elevated nitrate concentrations, the MDA will work with communities to design and initiate private well monitoring networks. This is a voluntary program and the actual number of partnerships will depend on interest and ability of individual or groups of townships.

Demonstration Sites: The MDA provides technical assistance and supports demonstration projects around the state. The Southeast Minnesota Nitrogen BMP Outreach Program is just one example of a demonstration and implementation program. MDA's goal is to work with local partners to support demonstration projects in areas with vulnerable groundwater.



Baseline

The baseline year for this measure is 2010. This year marked the beginning of Clean Water funding and the first year of each of the Clean Water funded nitrate monitoring and reduction activities.

Geographical Coverage

Many of these projects are targeted in areas of the state most vulnerable to groundwater contamination (Region 4 and Region 9 on the map). Dakota County is located in Region 10. Nitrate clinics and the township testing program are offered in many areas of the state.

Data and Methodology

Methodology for Measure Calculation

Data for this measure is collected from the contract and work plan for each individual project. The number of local partners will be calculated according to the number of partners identified in the formal contract (i.e. Joint Powers Agreement) and each partner that has a formal role in executing work described in the approved work plan.

Data Source

The MDA is the lead agency for this measure. All information is stored in contracts and work plans maintained by staff, supervisors, and contract specialist involved in the projects. Information is compiled by the Contracts Specialist position within the Pesticide and Fertilizer Division at the MDA. The MDA's Finance and Budget Division also retains all original contract information.

Data Collection Period

Data collection begins on the date a contract is executed. Data collection began July 1, 2009 and will continue for 25 year duration of the Clean Water Fund.

Data Collection Methodology and Frequency

Data will be collected at the time when contracts are executed and whenever any modifications are made to work plans. Updates will occur annually or at the time of reporting for the Clean Water Performance Report.

Supporting Data Set

There is no formal data set for this measure. Rather, MDA staff count the number of local partners participating in nitrate monitoring and reduction activities (supported by the Groundwater and Drinking Water appropriation in the Clean Water Fund).

Caveats and Limitations
This measure only accounts for formal partnerships with local government units. At this time, it does not account for partnerships with local co-ops, the University of Minnesota or other non-government units. This measure records partnership supported by the Groundwater and Drinking Water appropriation in the Clean Water Fund. It does not account for partnerships on projects in other appropriation categories such as Implementation or Monitoring/Assessment.

Future Improvements
None identified at this time

Financial Considerations

Contributing Agencies and Funding Sources
Minnesota Department of Agriculture is the only agency contributing data. Clean Water funding supports the partnerships identified in this measure.

Communication Strategy

Target Audience
State agencies, local government units, agricultural co-ops, farmers, researcher and the general public.

Associated Messages
State agencies work closely with local governments (LGUs) on all nitrate monitoring and reduction activities. Working with local government helps ensure that Clean Water funds are spent on priority projects that are relevant and important to community members. LGU's add value by providing expertise and knowledge of local issues.

Outreach Format
Newsletters, web pages, factsheets, Power Point presentations and reports are used to communicate information about nitrate monitoring and reduction projects.

- Quarterly updates are written for each project
- One page factsheets are available for each project
- Updates to web pages are made biannually or whenever significant activities occur
- Project staff prepare presentations for meetings and annual field days

Other Measure Connections
EDWOM 3: Changes over time in pesticides, nitrate and other key water quality parameters in groundwater
FM4: Total dollars awarded in grants and contracts to non-state agency partners

Measure Points of Contact

Agency Information

Bruce Montgomery
Manager, Fertilizer Nonpoint Section
Minnesota Department of Agriculture
Bruce.montgomery@state.mn.us

Ron Struss
Supervisor, Fertilizer Field Unit
Minnesota Department of Agriculture
Ron.Struss@state.mn.us

Margaret Wagner
Supervisor, Clean Water Technical Assistance Unit
Minnesota Department of Agriculture
Margaret.wagner@state.mn.us

Number of New Health-Based Guidance Values for Contaminants of Emerging Concern

Measure Background

Visual Depiction

Illustration of the molecular structure of compounds and pictures of consumer products or pharmaceuticals.

Measure Description

Active research combined with our increasing ability to measure minute amounts of chemicals in water raises concerns about people's exposure to very low levels of chemicals or mixtures of chemicals over a long period of time, especially during vulnerable periods like fetal development. This measure tracks the number of contaminants of emerging concern for which the Minnesota Department of Health (MDH) has conducted toxicity and exposure evaluations resulting in health-based guidance for drinking water.

Associated Terms and Phrases

Contaminant of Emerging Concern (CEC): A substance that has been released to, found in, or has the potential to enter Minnesota waters (groundwater and surface water), characterized by:

- a perceived or real threat to public health;
- no Minnesota drinking water health-based guidance currently exists or existing guidance needs to be updated to reflect new toxicity or occurrence information;
- insufficient or limited toxicological information or toxicity information that is evolving or being re-evaluated; or,
- significant new source, pathway, or detection limit information.

Health Based Values (HBVs): HBVs are concentrations of a contaminant in water that pose little or no health risk to a person drinking that water, including sensitive or highly exposed populations such as pregnant women and infants.

Health Risk Limits (HRLs): HRLs are HBVs that are promulgated through a formal rulemaking process authorized in the 1989 Groundwater Protection Act (GWPA). Per the GWPA, MDH's authority to promulgate HRLs is limited to chemicals that have been detected in groundwater in Minnesota.

Risk Assessment Advice (RAA): RAA is the concentration of a contaminant in water that pose little or no health risk to a person drinking that water, including sensitive or highly exposed populations. RAA may include a numerical value or may be a written (qualitative) description of the risk posed by a

specific contaminant. RAA may be based on more limited toxicity data than HBVs or HRLs, or may use new risk assessment methods that are not included in the HRL rules.
Rapid Assessment: Screening level values for pesticides and pharmaceutical ingredients derived using specific MDH developed methodologies tailored for faster analysis. Designed to be conservative and provide risk context to environmental detections.
Re-evaluation: Effort to keep existing health-based guidance values up-to-date with current MDH methodology and the available science. Results in updates to existing guidance or a recommendation for in-depth review. Occurs on a regular basis every few years, per the GWPA.

Target

Develop health-based guidance for ten contaminants every biennium. Guidance was developed for the following substances in the FY10-11 biennium:

1. acetaminophen,
2. 6-acetyl-1,1,2,4,4,7-hexamethyltetraline (AHTN or Tonalide),
3. carbamazepine,
4. N,N-diethyl-meta-toluamide (DEET),
5. 1,4-dioxane,
6. metribuzin degradates,
7. pyraclostrobin,
8. tris(2-chloroethyl) phosphate (TCEP),
9. 1,2,3-trichloropropane (1,2,3-TCP), and
10. triclosan.

Guidance was developed for the following substances in the FY12-13 biennium:

11. bisphenol A (BPA),
12. butyl benzyl phthalate (BBP),
13. dibutyl phthalate (DBP),
14. microcystin,
15. propyl paraben,
16. skatol,
17. sulfamethazine,
18. sulfamethoxazole,
19. triclocarban,
20. tris(1,3-dichloroisopropyl)phosphate (TDCPP).

Guidance was developed for the following substances in the FY14-15 biennium:

21. acrylamide,
22. bisphenol A (BPA) (revised due to new information),
23. chlorpyrifos,
24. chlorpyrifos oxon,
25. desvenlafaxine,
26. di(2-ethylhexyl)phthalate (DEHP),

27. isobutanol,
28. nonylphenol,
29. triclosan (revised due to new information), and
30. venlafaxine.

Guidance was developed for the following substances in the FY16-17 biennium:

31. anatoxin-a,
32. aminomethylphosphonic acid (AMPA),
33. dichlorofluoromethane (DCFM),
34. 2,4-dichlorophenoxyacetic acid (2,4-D),
35. 17a-Ethinylestradiol,
36. mestranol,
37. microcystin (revised due to new information),
38. perfluorooctanoic acid (PFOA),
39. perfluorooctane sulfonate (PFOS),
40. 4-tert-octylphenol, and
41. tetrahydrofuran.

Additionally, 20 contaminants are proposed to be screened each biennium. The following substances were screened in the FY10-11 biennium:

1. bisphenol A (BPA),
2. butyl benzyl phthalate (BBP),
3. cadmium,
4. decabromodiphenyl ether (decaBDE),
5. dibutyl phthalate (DBP),
6. di(2-ethylhexyl)phthalate (DEHP),
7. formaldehyde,
8. hexabromocyclododecane (HBCD),
9. lead,
10. propyl paraben,
11. skatol,
12. sulfamethoxazole, and
13. triclocarban.

The following substances were screened in the FY12-13 biennium:

14. bupropion,
15. chlorpyrifos,
16. chlorpyrifos oxon,
17. colloidal silver,
18. copper sulfate,

19. 2,4-dichlorophenoxyacetic acid (2,4-D),
20. diquat,
21. endothall,
22. estrone,
23. 17 alpha-ethinylestradiol,
24. fluoxetine,
25. fluoridone,
26. glyphosate,
27. imazapyr,
28. microcystin,
29. nanosilver,
30. nonylphenol,
31. nonylphenol mono-ethoxylate (NP1EO),
32. nonylphenol di-ethoxylate (NP2EO),
33. octylphenol,
34. thiamethoxam,
35. triclopyr,
36. trimethoprim,
37. tris(1,3-dichloroisopropyl)phosphate (TDCPP), and
38. venlafaxine.

The following substances were screened in the FY14-15 biennium:

39. acrylamide,
40. benzophenone,
41. 1H-benzotriazole (BT),
42. biphenyl,
43. codeine,
44. diallyl dimethyl ammonium chloride (DADMAC),
45. diphenhydramine,
46. hexabromocyclododecane (HBCD) (rescreened due to new information),
47. hexahydrohexa-methyl cyclopenta-benzopyran (HHCB),
48. isobutanol,
49. 5-methyl-1H-benzotriazole,
50. metoprolol,
51. nanosilver (rescreened due to new information),
52. n-nitrosodimethylamine (NDMA),
53. 4-nonylphenol monoethoxy-carboxylate (NP1EC),
54. 4-nonylphenol diethoxy-carboxylate (NP2EC),
55. 4-nonylphenol triethoxy-carboxylate (NP3EC),
56. perfluorohexane sulfonate (PFHxS),

57. polydiallyl dimethyl ammonium chloride (pDADMAC),
58. propyl paraben (rescreened due to new information),
59. tetrahydrofuran, and
60. tris(2-butoxyethyl) phosphate (TBEP).

The following substances were screened in the FY16-17 biennium:

61. amitriptyline,
62. anatoxin a,
63. androstenedione,
64. bifenthrin,
65. bromoform,
66. carbadox,
67. chlorate,
68. chlorinated parrafins (long chain),
69. chlorinated parrafins (medium chain),
70. chlorinated parrafins (short chain),
71. chloroanil,
72. copper sulfate (rescreened due to new information),
73. decabromodiphenyl ethane (DBDPE),
74. 17b-estradiol,
75. estrone (rescreened due to new information),
76. iopamidol,
77. lincomycin,
78. metformin,
79. methyl paraben,
80. 2-propen-1-ol (allyl alcohol),
81. propyl paraben (rescreened due to new information),
82. nanosilver (rescreened due to new information),
83. strontium, and
84. tributyl phosphate (TBP).

Additional Guidance Work

Rapid Assessments

MDH developed methodologies to derive rapid assessment values for pesticides as well as for active pharmaceutical ingredients. To date, MDH has derived rapid assessment values for 119 pharmaceutical ingredients and 181 pesticides. The count reflects active rapid assessment values. Rapid assessment values are removed if a health-based water guidance value is later developed for the contaminant.

Guidance Re-evaluations

MDH re-evaluates existing health-based guidance values derived after 2008 on a regular schedule to ensure that the guidance is up-to-date with current MDH methodologies and the current available science. Incorporating new data and updating methodology may result in changes to existing guidance values. A re-evaluation may also result in a recommendation that the guidance be assessed in a more in-depth review.

The following substances with existing guidance values were re-evaluated in the FY16-17 biennium:

1. acetochlor,
2. acetochlor ethanesulfonic acid (ESA),
3. acetochlor oxanilic acid (OXA),
4. alachlor,
5. alachlor ethanesulfonic acid (ESA),
6. alachlor oxanilic acid (OXA),
7. benzo[a]pyrene,
8. chloroethane,
9. chloroform,
10. cyanazine
11. 1,1-dichloroethane,
12. dichlorofluoromethane (DCFM),
13. dieldrin,
14. ethyl ether,
15. pyraclostrobin,
16. 1,1,1-trichloroethane,
17. 1,2,4-trimethylbenzene,
18. 1,3,5-trimethylbenzene, and
19. vinyl chloride.

Baseline

While historically MDH only developed guidance for contaminants found in groundwater and when there was no state standard, Clean Water funding allows MDH to provide guidance that will help regulatory agencies prevent harmful levels of emerging contaminants in all Minnesota waters, including surface water and groundwater, and provide a human health context for research and monitoring efforts. Beginning in 2009, funding from the Clean Water amendment added staff and resources to support this expanded effort.

Geographical Coverage

This activity is relevant to the entire state.

Data and Methodology

Methodology for Measure Calculation

Health risk assessment methodology used to develop guidance is consistent with the methodology promulgated as part of the HRL rule (Minnesota Administrative Rules, Parts 4717.7810 through 4717.7900).

Data Source

Information on the process used and contaminants assessed is available in periodic reports for the public authored by the Health Risk Assessment Unit's Contaminants of Emerging Concern staff. Numerous data sources are used to develop health based guidance, depending on the availability of applicable toxicological studies. Sources of data for each chemical are listed in toxicity summaries and information sheets intended for the public and posted on MDH web pages.

Data Collection Period

July 2009-June 2017

Data Collection Methodology and Frequency

MDH relies on occurrence information from ongoing groundwater and surface water monitoring conducted by the Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Agriculture (MDA). Contaminants evaluated through the program include chemicals nominated by the MPCA and MDA for which they need guidance information to evaluate the results of their monitoring and regulatory efforts. MDH has also used monitoring data that is available from various research projects conducted by the United States Geological Survey (USGS), American Water Works Association (AWWA), and academic institutions. Toxicological studies are available from various data sources.

Supporting Data Set

The toxicological data used by MDH is described in toxicological summary sheets available for each contaminant assessed. The occurrence data accessed by MDH is described in public information sheets. Information sheet development is a collaborative effort with MPCA and MDA. Both types of information are posted online as links on the water guidance table (www.health.state.mn.us/divs/eh/risk/guidance/gw/table.html).

Caveats and Limitations

Currently, MDH has restricted its use of funding for research on contaminants of emerging concern to evaluating health based guidance for contaminants that have the potential to impact drinking water. For some contaminants, the route of exposure of greatest concern may be something other than drinking water such as use of a consumer product that contains the chemical. Additionally, for some contaminants of emerging concern there may not be sufficient published and peer reviewed toxicological data available to develop numeric health-based guidance. In these instances, it is anticipated that qualitative guidance will be provided as applicable and available.

Future Improvements

The work of the program continues to evolve and improve. Two task groups and an advisory forum have been convened and have provided advice and input on the work of the program. The task groups are temporary in nature but public forums have been and will continue to be held annually. Additionally, some work of the program is conducted by contracted research and outreach and education grants. The outreach and education grants focus specifically on enhancing Minnesotans' understanding and knowledge of contaminants of emerging concern in water that may be used for drinking. These grants:

- raise awareness of emerging contaminants, how they enter the environment, and their potential health impacts;
- highlight the value of clean drinking water and how MDH activities contribute to Minnesota's clean water; or
- promote individual, family, and community behaviors that reduce environmental releases of emerging contaminants.

Financial Considerations

Contributing Agencies and Funding Sources

This effort is entirely supported by Clean Water amendment funding, with some in-kind contributions of staff supported by the state general fund. Such in-kind enhancement is particularly necessary to ensure that the CEC program work is conducted in a manner consistent with other water quality guidance and rule making work of the department.

Communication Strategy

Target Audience

Audiences include the legislature, the public, and water resources, environmental, and public health professionals (state, local and federal agencies, academic institutions, nonprofit organizations, private industry, general practitioners, and public health nurses).

Associated Messages

The exposure and toxicity information generated from this measure can be used to inform consumer activity as well as the environmental regulation and monitoring activities of government entities and academic institutions. The human health-based guidance and risk assessment advice for water provided through this measure clarifies the potential risk from exposure to contaminants of emerging concern through this medium.

Outreach Format

Information regarding this measure is communicated via a program website, factsheets (including contaminant specific factsheets), an email list serve, an advisory forum, interagency communications, and presentations at conferences and other events.

Other Measure Connections

This measure does not specifically link to other measures but is an integral component of ambient water, source water, and drinking water protection efforts. Monitoring activities conducted by MPCA include contaminants of emerging concern.

Measure Points of Contact

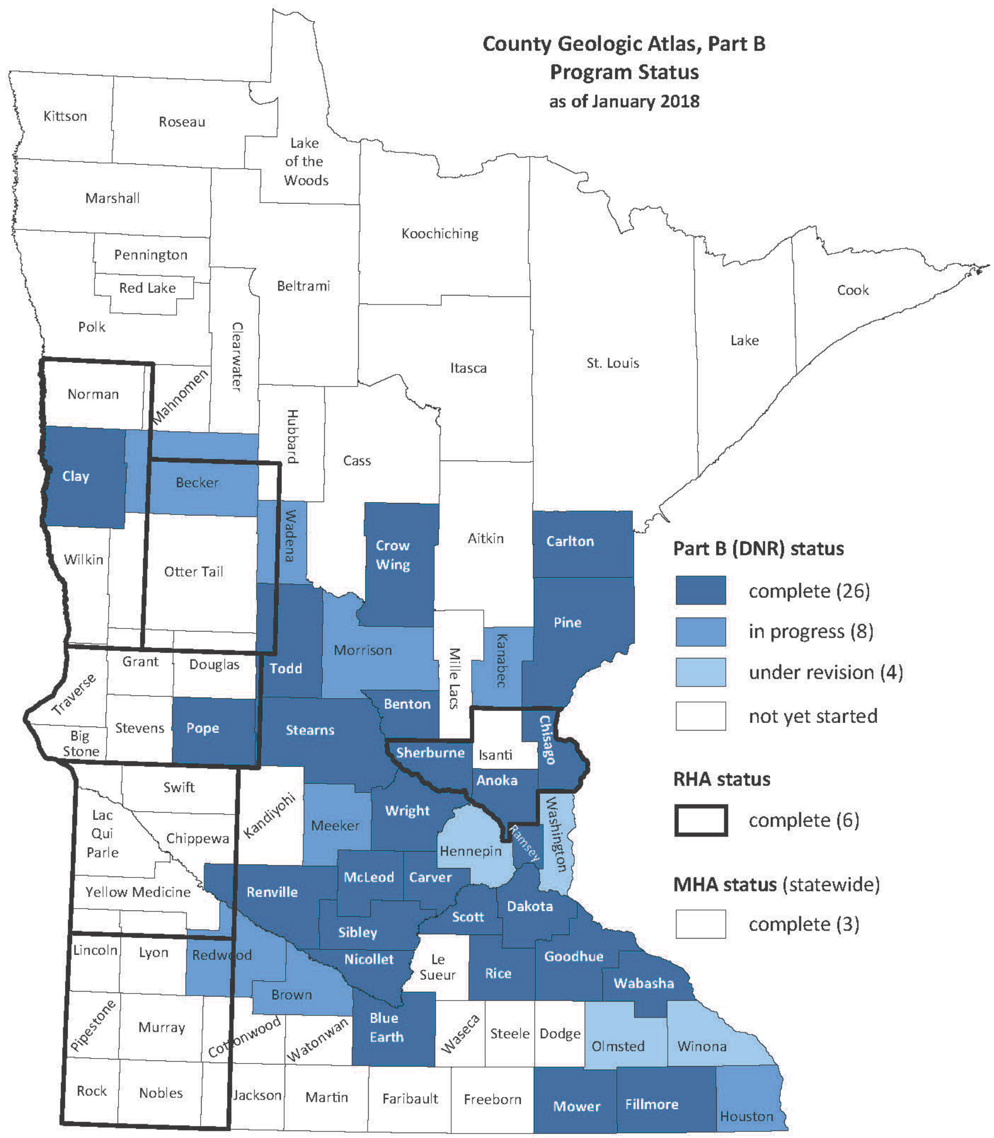
Agency Information

Katie Nyquist, katie.nyquist@state.mn.us, 651-201-4898

County Geologic Atlas for Groundwater Sustainability

Measure Background

Visual Depiction



This measure can be depicted as a statewide map for a specific point in time, as shown above for January 2018, or as a time series plot that shows the amount of work
Approximately 38 Part A atlases have been completed by the MGS. And, as of January 2018 (see above figure), 26 atlases (Part B) have been completed, and another 12 are underway or being updated. The table below shows how the number of counties where geologic atlas Part B work since 2009, the baseline year.

Fiscal Year	Counties with a completed Geologic Atlas Part B	Percent of counties with completed Geologic Atlas Part B
FY09	16	17.9
FY10	17	19.1
FY11	18	20.2
FY12	19	21.3
FY13	20	22.5
FY15	22	24.7
FY17	26	29.2

Measure Description

Groundwater resources in Minnesota are critical for meeting drinking water, industrial, and agricultural needs, and the needs of groundwater-dependent ecological communities. Groundwater and surface water resources are linked, forming a large, inter-connected, system. Nevertheless, our knowledge of groundwater resources in many parts of Minnesota is limited. Our ability to fully utilize groundwater resources to support Minnesota's economies and communities, while insuring long-term resource sustainability and avoiding adverse impacts on ground-water dependent ecological communities, is limited by the lack of detailed geologic or groundwater information.

This measure tracks the extent to which this critical data assessment process has been completed for the state. Individual counties self-select for completing a county geologic atlas by making a commitment to provide in-kind services such as confirming the location of wells from Minnesota Department of Health well records.

Associated Terms and Phrases

Groundwater: All water beneath the land surface.

County geologic atlas: A comprehensive report of a county's geology (Part A) and groundwater resources (Part B).

Groundwater sustainability: Groundwater use that prevents degradation, avoids unacceptable consequences, does not compromise future use, and does no harm to ecosystems.

Target

The long-term goal is to complete a County Geologic Atlas for every county in Minnesota in 10 to 15 years. The current target for achieving that goal is to complete three or four atlases per year.

Baseline

2009 was selected as the baseline year because it represents when the Minnesota Legislature (2009) first appropriated Clean Water Legacy funds to help develop County Geologic Atlases. At that time, sixteen county geologic atlases were completed (representing 17.9 percent of the state's counties).

Geographical Coverage

The measure is statewide although the work is done at the county scale because it is designed to inform water-use decisions being made by local communities that use counties as political boundaries.

Data and Methodology

Methodology for Measure Calculation
The percent area of the counties with geological atlas a completed or in progress is assessed annually.

Data Source
DNR's Division of Ecologic and Water Resources tracks this activity.

Data Collection Period
The period of interest are fiscal years beginning in FY10 and continuing.

Data Collection Methodology and Frequency
The measure is the calculated percent of counties with completed county geologic atlases.

Supporting Data Set
For an updated list of counties with completed geologic atlases, please refer to:

- MGS Part A: http://www.mngs.umn.edu/county_atlas/countyatlas.htm
- DNR Part B: http://www.dnr.state.mn.us/waters/groundwater_section/mapping/index.html

Caveats and Limitations
The current program plan is to complete a county geologic atlas for all 87 of the state's counties.

Future Improvements
Older atlases will be revised as new information becomes available.

Financial Considerations

Contributing Agencies and Funding Sources
County geologic atlases are a cooperative effort between the Minnesota Department of Natural Resources (DNR) and the Minnesota Geological Survey (MGS). The MGS completes Part A (geology) which is followed by DNR completing Part B (groundwater). Funding for the work comes from multiple sources and has varied over time. The Clean Water Legacy funding is allowing the effort to be accelerated and more detailed data to be collected, such as the use of sophisticated geological coring.

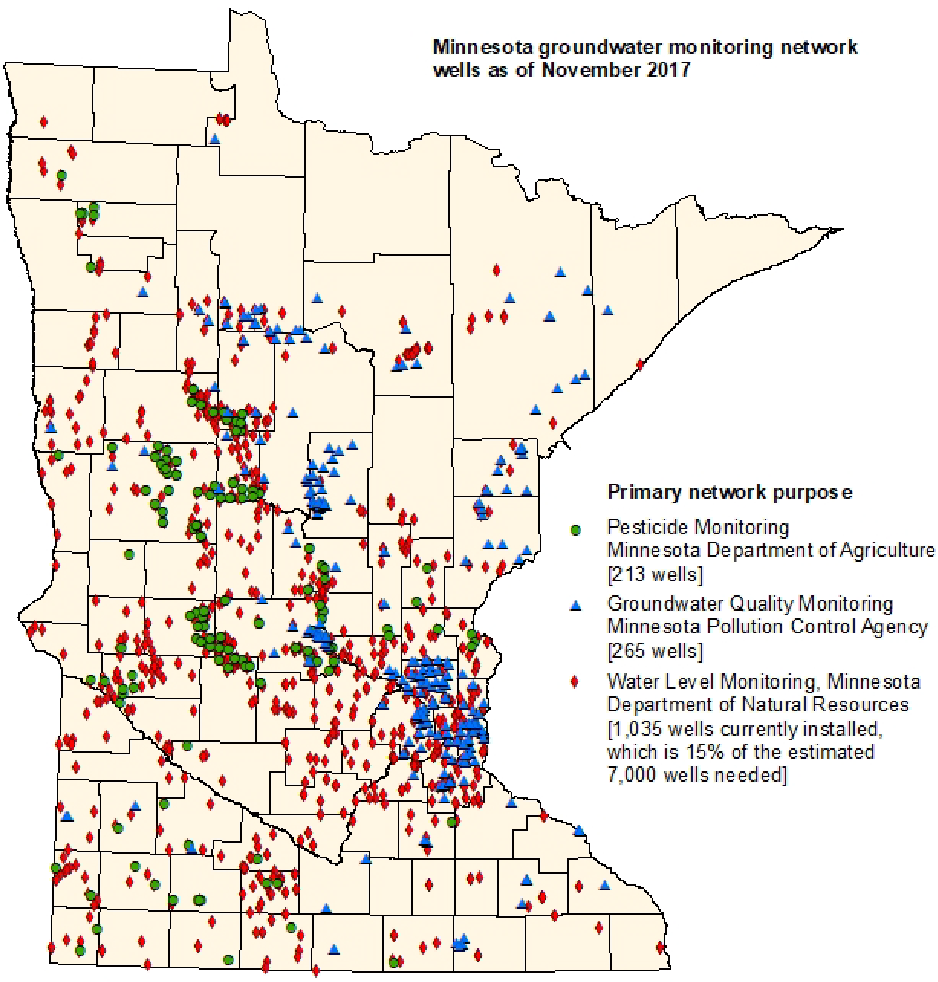
Measure Points of Contact

Agency Information
Point of Contact: Paul F. Putzier, P.G., Supervisor
paul.putzier@state.mn.us
http://www.dnr.state.mn.us/waters/groundwater_section/mapping/index.html

Number of long-term groundwater monitoring network wells in Minnesota

Measure Background

Visual Depiction



Minnesota groundwater monitoring network wells as of November 2017

Measure Description

This measure represents the current distribution of wells used by state agencies to monitor long-term trends in water quality and aquifer levels. 1,513 wells are currently used to monitor long-term groundwater conditions. Going forward, this measure will illustrate how gaps in groundwater information are filled.

Well installation, water quality sampling and water level measurement are coordinated between state agencies and wells are used for multiple purposes whenever feasible. Other monitoring wells exist, but they are used for short-term, contamination identification or remediation activities.

This measure illustrates how Clean Water Fund investments accelerate efforts to fill gaps in our understanding of aquifer conditions across the state and improve local capacity to improve private and public drinking water supply infrastructure development. While Minnesota's groundwater monitoring network is still inadequate for understanding groundwater conditions in portions of the state, it is improving.

Associated Terms and Phrases

Aquifer: Rock or sediment that is saturated with water able to transmit economic quantities of water to wells and surface waters.
Groundwater: Water stored in the pore spaces of rocks and unconsolidated deposits found in the saturated zone of an aquifer.
Monitoring network: Set of monitoring wells, managed by multiple state agencies, used to repeatedly measure groundwater quantity and quality over the long-term.
Monitoring well: In this measure, the term 'monitoring well' refers to any well which is actively used to collect information about groundwater parameters such as chemistry, contamination, temperature, water level, etc. over the long term. Different agencies use a variety of terms for monitoring wells, and each term may have a different programmatic or legal definition. Wells used for short-term, contamination identification or remediation activities are not considered to be monitoring wells for the purpose of this measure.
Ob Well: An abbreviated version of "observation well", commonly used by the MN Department of Natural Resources when referring to wells in their groundwater level monitoring network. The term may also be used by other agencies when referring to any groundwater monitoring well.
Observation Well: Another term for "monitoring well". It is used by all agencies and particularly by the MN Department of Natural Resources when referring to wells in their groundwater level monitoring network.

Target

Minnesota Department of Natural Resources (DNR) currently monitors aquifer levels in 1,035 wells, which is 15% of the estimated 7,000 wells needed.

Minnesota Pollution Control Agency (MPCA) currently monitors water quality in 260 wells. The system is being expanded to result in a completed network of about 270 wells.

The Minnesota Department of Agriculture (MDA) manages a long-term monitoring network of 213 wells. This network is being expanded to target an additional 260 townships with vulnerable groundwater and row crop agriculture over the next four years, as part of the Nitrogen Fertilizer Management Plan. In these townships, MDA will partner with private well owners to monitor approximately 70,000 wells.
The current statewide groundwater monitoring network includes 1,513 wells.
The ultimate goal is a network of approximately 7,400 state-owned and managed long-term groundwater monitoring wells and over 70,000 private well monitoring partnerships.

Baseline

The baseline year for reporting the number of new monitoring wells installed is 2013. This year will serve as the baseline data set for future monitoring.

Geographical Coverage

The measure is statewide.

Data and Methodology

Methodology for Measure Calculation

Minnesota Department of Health (MDH) creates the map using data provided and maintained by the MPCA, the MDA and the DNR. For this map project, these data were reviewed to identify active wells currently used for long-term monitoring of groundwater conditions. Map updates will continue to require data from each of these agencies.

Data Source

MDH periodically compiles state agency groundwater monitoring well GIS data, which is available upon request. The dataset does not have a formal name but is referred to by the map title "Minnesota Groundwater Monitoring Network Wells as of July 2013". This dataset should be considered raw data that may not include the refinements described above in the "Methodology" section.

The respective agencies should be contact for information about more current data.

Data Collection Period

Through November 2017.

Data Collection Methodology and Frequency

Data is added to the MDH state agency groundwater monitoring well GIS data set on an ad hoc basis as new wells are installed or as updated information about existing wells is provided by partner agencies.

Supporting Data Sets

MDA monitoring well information is stored in the Minnesota Pollution Control Agency's EQUIS database. Annual monitoring reports are produced by MDA and posted on their website.

DNR water-level data are stored in an observation-well database maintained by the Ecological and Water Resources Division and provided on their website. Over the coming year, these data will be migrated to the State Cooperative Water Data System (Hydstra) and a new web interface will be developed. Old data is still available from the current site at http://climate.umn.edu/ground_water_level/.
MPCA provides public access to a wide variety of data on environmental conditions through Environmental Data Access. MPCA collects a variety of data on groundwater quality, which is available online at http://www.pca.state.mn.us/index.php/data/groundwater.html.

Caveats and Limitations

Other monitoring wells exist, but they are used for short-term, contamination or remediation activities.

Future Improvements

In the future, the groundwater level observation well network may include MPCA wells where contamination investigation is ongoing and where water level information is collected.

Financial Considerations

Contributing Agencies and Funding Sources

The DNR groundwater-level monitoring program is funded by a mix of Clean Water Fund, bonding, and the General Fund. Observation-well construction costs have been supported by designated bonding funds. Clean Water Fund money also supports planning and maintenance of the observation-well network and program coordination.

The MPCA's long-term groundwater monitoring well network is supported by the Clean Water Fund

The MDA's monitoring network is designed specifically for pesticides and is funded using dedicated fees on pesticides.

Communication Strategy

Target Audience

The target audience for these groundwater observation well distribution results includes, but is not limited to, community public water systems, consulting engineers, academia, policy makers, and the general public.

Associated Messages

While Minnesota's groundwater monitoring network is still inadequate for understanding groundwater conditions in portions of the state, it is improving.

Public and private well owners should regularly review local groundwater information and use the data as a tool to assess the need for future well maintenance or water treatment. For example, if the data collected at a nearby groundwater level observation well shows a long-term drop in water level, the pump may eventually need to be lowered or the well drilled deeper.

Other Measure Connections

The results of this measure may be examined in conjunction with other measures documenting surface water and groundwater quality and quantity. For example, changes in overall trend in Minnesota's aquifer levels or groundwater quality may be impacted by a change in the number and distribution of the state's monitoring well network.

Outreach Format

Information regarding groundwater levels is provided on the Minnesota Department of Natural Resources website: http://www.dnr.state.mn.us/waters/groundwater_section/obwell/index.html

Information regarding groundwater quality is provided on the Minnesota Pollution Control Agency website: https://www.pca.state.mn.us/water/groundwater-data

Information regarding groundwater quality monitoring is provided on the Minnesota Department of Agriculture website:
http://www.mda.state.mn.us/protecting/cleanwaterfund/~/link.aspx?_id=23D8B64273814B09B4FBD954DAA29396&_z=z

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Measure Points of Contact

Agency Information

Tannie Eshenaur, tannie.eshenaur@state.mn.us
651.201.4074
On behalf of the Clean Water Fund Interagency Groundwater Drinking Water team

Number of Unused Groundwater Wells Sealed

Measure Background

Visual Depiction

Picture or graphic of a well or a cross section showing how an open well can allow contaminants to reach groundwater or a graph of cumulative wells sealed.

Measure Description

This measure tracks the number of unused wells and borings sealed in Minnesota. Unused wells, sometimes called "abandoned" wells, can pose a serious threat to groundwater quality. Unused wells provide a pathway for contaminants to travel deep into groundwater, bypassing the natural protection usually provided by layers of clay, silt, and other geologic materials. This pathway can threaten water quality in city water wells, wells that serve local businesses, and private wells that serve individual homes. Sealing unused wells helps protect groundwater and drinking water sources from contaminants.

Associated Terms and Phrases

Sealing: The process of preparing a well to be filled with grout and the process of filling a well with grout. In Minnesota, wells must be sealed by a licensed well contractor. Before sealing the well, the contractor will remove any pumping equipment that may still be in place and remove any debris or other obstructions from the well. The contractor then seals the well by pumping grout into the well.

Well: A drilled, cored, bored, washed, driven, dug, jetted, or otherwise constructed excavation that is intended for the location, diversion, artificial recharge, or acquisition of groundwater. Wells include monitoring wells, drive point wells, and dewatering wells.

Target

To seal all unused wells in Minnesota.

Baseline

The number of wells sealed before Clean Water Fund dollars became available for well sealing grants.

Geographical Coverage

Statewide

Data and Methodology

Methodology for Measure Calculation

The total number of wells sealed each year, as reported to the Minnesota Department of Health (MDH) will be compared to the number of wells reported sealed through grants funded by the Clean Water Fund.

Data Source

MDH receives all well sealing records and records the information in the Minnesota Well Index. The Board of Water and Soil Resources keeps record of the number of private wells sealed with Clean Water funds and will pass the information along to MDH. The number of public water supply wells sealed will be reported directly to MDH.

Data Collection Period

July 1, 2011 to June 30, 2016

Data Collection Methodology and Frequency

A well sealing form is submitted to MDH for each well sealed in the state. In addition, a requirement of the Clean Water Fund well sealing grants is to report the number and type of wells sealed with those funds. These two sources of information will be compared on an annual basis.

Supporting Data Set

NA

Caveats and Limitations

NA

Future Improvements

NA

Financial Considerations

Contributing Agencies and Funding Sources

NA

Communication Strategy

Target Audience

NA

Associated Messages

NA

Outreach Format

TBD

Other Measure Connections

Measure Points of Contact

Agency Information

Chris Elvrum
Manager, Well Management Section
Environmental Health Division
Minnesota Department of Health
chris.elvrum@state.mn.us

Changes over time in pesticides, nitrate and other key water quality parameters in groundwater

Measure Background

Reporting on this measure will be the responsibility of both the Minnesota Department of Agriculture (MDA) and the Minnesota Pollution Control Agency (MPCA). Each agency has a unique groundwater monitoring program, which is designed for a specific purpose and to meet specific objectives. The agencies also have a monitoring agreement to coordinate monitoring activities. Whenever possible, data will be colligated between the two programs. However, there will be many instances when MDA and MPCA data will be reported separately.

In general, the MDA's pesticide monitoring program analyzes samples for pesticides that are widely used and/or pose the greatest risk to groundwater or surface water. The MDA follows a pesticide selection process which prioritizes the specific compounds to be tested. Common compounds include pesticides applied in agricultural settings and those applied to lawns and gardens. The MDA's water quality monitoring program is designed specifically to evaluate pesticides; however, analysis of nitrate is also conducted. The MDA has also initiated an extensive program for monitoring nitrate concentrations in private drinking water wells.

The MPCA manages a network of groundwater monitoring wells that measure ambient (or background) conditions for non-agricultural parameters, and is focused on two aquifers that are vulnerable to anthropogenic contamination—the sand and gravel and Prairie du Chien-Jordan aquifers. Some wells in the MPCA's network are monitored to discern the effect of urban land use on groundwater quality and comprise an early warning network. The early warning network was designed using a random stratified statistical approach to determine the effects of land use (sewered residential, residential areas on subsurface sewage treatment systems, commercial/industrial, and undeveloped) and the composition of the sand and gravel aquifers (these aquifers vary in composition depending upon which glacial advance deposited the sediments) on groundwater quality. The MPCA portion of this measure will report on the changes in nitrates, chloride, volatile organic compounds, and contaminants of emerging concern in vulnerable aquifers. Reporting ambient groundwater trends for nitrates, chloride, volatile organic compounds and emerging contaminants will begin in 2014.

There are some important differences between the monitoring programs at the MDA and MPCA. The MPCA's network deliberately focuses on urban and undeveloped parts of the State since their role is to provide information on non-agricultural chemicals. The MDA program is designed to evaluate the impact to groundwater from the normal use of pesticides and fertilizer, with an emphasis on the impacts from agricultural crops such as corn, in areas vulnerable to groundwater contamination. The MDA has been collecting groundwater monitoring data, primarily for pesticides, for this purpose since 1985. The MDA currently has groundwater quality trend data extending over 20 years, which is exceedingly rare, and publishes an annual report which summarizes this data. This data is important for evaluating the long term effects of agricultural practices on groundwater quality.

Due to the large amount of data that is available and the many water quality parameters that could be reported on, it is possible that sub-measures may eventually be developed. Possible sub-measures are:
1) Trends in the concentration and detection of common detection pesticides in groundwater

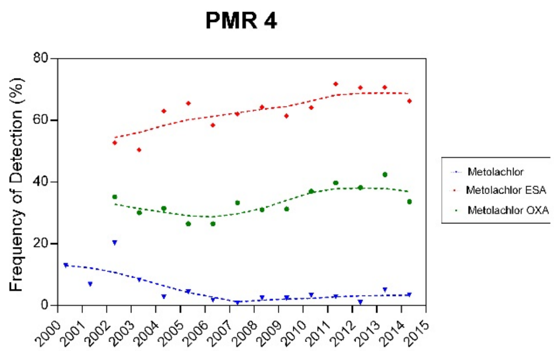
(EDWOM3a), 2) Trends in concentration of nitrate-nitrogen in groundwater (EDWOM3b), and 3) Changes in chloride, volatile organic compounds, and emerging contaminants of vulnerable aquifers (EDWOM3c).

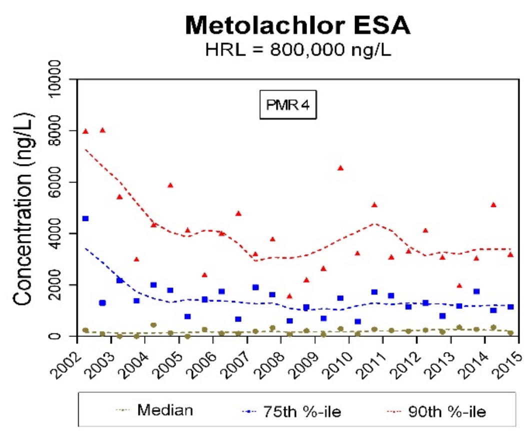
Visual Depiction

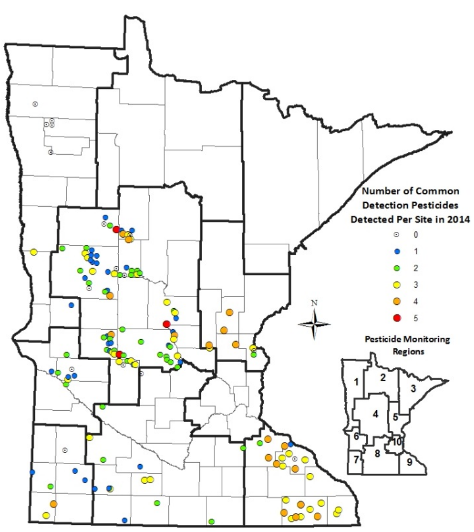
Below are examples of the graphical and tabular representation of data for this measure.

Example graphics for common detection pesticides in groundwater over time.

Each pesticide that is in Common Detection will have similar graphs and tables prepared for the analysis of trends over time.





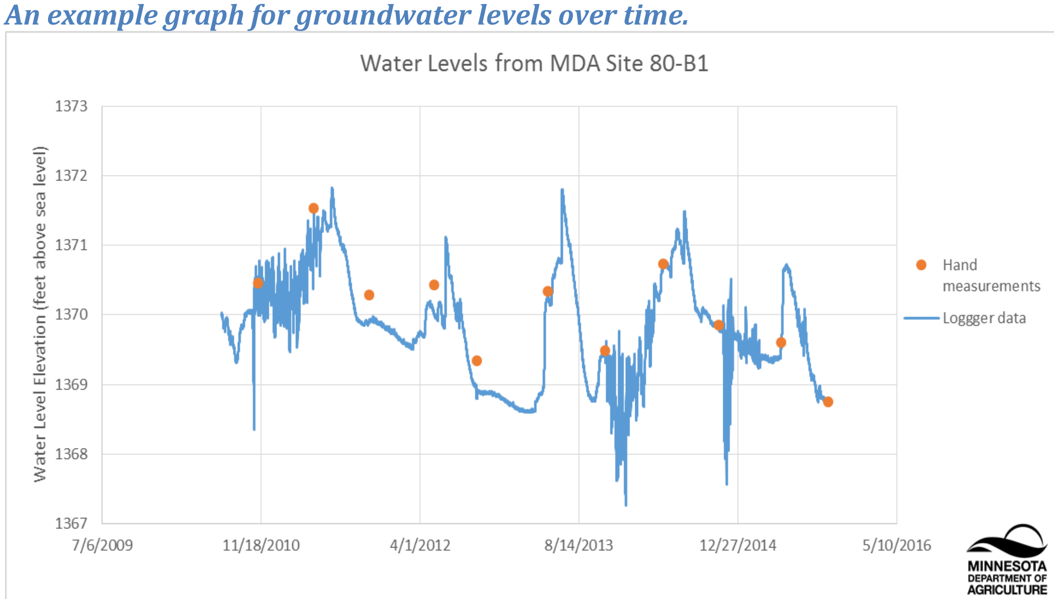


An example of results of trend analysis of a pesticide in groundwater.

Parameter	M-K stat	Kendall Tau	Slope estimate

Parent Median	76	0.33	0
Parent 75th %-ile	-110	-0.48	-0.001
Parent 90th %-ile	-137	-0.59	-0.003
Parent Detection Frequency	72	0.31	1.55
Degradate 1 Median	-134	-0.58	-0.002
Degradate 1 75th %-ile	-162	-0.70	-0.004
Degradate 1 90th %-ile	-183	-0.79	-0.007
Degradate 1 Detection Frequency	48	0.21	0.75
Degradate 2 Median	-5	-0.02	0
Degradate 2 75th %-ile	-73	-0.32	0
Degradate 2 90th %-ile	-130	-0.56	-0.009
Degradate 2 Detection Frequency	-99	-0.43	-1.84

An example graph for groundwater levels over time.



Measure Description

Pesticides

This measure consists of graphics and tables displaying pesticide concentration and detection over time. Coupled with trend calculations the graphics provide a rapid determination of tendency in groundwater monitoring results for pesticides. This measure is intended for pesticides that have been detected frequently enough to be designated as commonly detected in Minnesota groundwater. As of January 2018, five pesticides and their degradates, including acetochlor, alachlor, atrazine, metolachlor and metribuzin, have been placed in Common Detection in Minnesota groundwater. Specific pesticides in Common Detection status may change over time.

The pesticide portion of this measure does not evaluate the condition of drinking water but only the shallowest groundwater at the edges of fields in highly sensitive geological areas.

Nitrates

This measure consists of graphics and tables displaying nitrate concentrations over time. This measure will include nitrate data from multiple networks. This includes data collected statewide as part of MDA's water quality monitoring program and also data from more intensive sampling in areas where private well networks are established or in townships with greater than 20% row crop agriculture and vulnerable groundwater.

Background on Private Well Networks

- The Southeast Minnesota volunteer monitoring network (SE MN Monitoring Network) is distributed across nine counties in southeastern Minnesota and began in 2008 in cooperation with the Southeastern Minnesota Water Resources Board (SEMNWRB). The network is a set of private wells selected by location and owner willingness to participate. The same wells are sampled annually as long as the owner continues to participate. Approximately 300 to 400 wells have been sampled during each round (sampling event) in recent years. This network was established to track nitrate concentrations in the drinking water of the karst region of the state. Results from this program can be used to make conclusions about nitrate trends in drinking water across the region.
- The current Central Sands private well monitoring network began nitrate sampling in spring of 2011. The initial sampling set the stage for a long-term monitoring network. The network is distributed across 14 counties in central Minnesota. Selection of individual wells was random and the network is designed to complement the MDA monitoring well data. Approximately 400 private wells have been sampled annually in recent years. The Central Sands private well monitoring project emphasizes sampling groundwater that people are drinking. Results from this program can be used to make conclusions about nitrate trends in drinking water across the region.
- As outlined in the Nitrogen Fertilizer Management Plan (2013), MDA has begun to conduct private drinking water well sampling in vulnerable areas with significant row crop agriculture, generally using the township as the primary geographic boundary in order to evaluate current nitrate conditions. This is called the Township Testing Program. These efforts will be conducted on a cooperative basis with the assistance of local government units and other agencies. Based on the results of one round of sampling, MDA will determine the appropriate mitigation response.
- The Township Testing Program began in 2013; the long term goal will be to survey every vulnerable township at least once every 10 years in synch with the Minnesota Pollution Control Agency's 10 year watershed monitoring cycle. MDA plans to target water samples from

approximately 70,000 private wells, in about 275 vulnerable townships, between 2013 and 2020. It is important to note that this approach is focused on the most sensitive areas of the state and data collected will only be used to make conclusions about nitrate trends in drinking water in the townships sampled. In 2014, MDA also began collecting pesticide samples from select private wells that had detectable nitrate as part of the Township Testing Program.

Chloride, Volatile Organic Compounds and Emerging contaminants

This measure consists of graphics and statistics displaying trends in chloride concentrations, VOCs, and contaminants of emerging concern detections over time.

Associated Terms and Phrases

Common detection refers to common detection as defined in Minnesota Statutes Section 103H and further described within the Minnesota Pesticide Management Plan.

Contaminant of Emerging Concern is any synthetic, naturally-occurring chemical or microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human-health effects. In some cases, the release of emerging contaminants has occurred for a long time but may not have been detected until new laboratory methods were developed.

Groundwater quality refers to the chemical condition of water beneath the ground surface regardless of the use of the water. This measure does not refer to, or necessarily reflect, the general condition of drinking water in the state or any sub-state region.

Pesticides in groundwater refers to pesticides that are present in groundwater as a result of routine application and not some unusual or unique circumstance.

Pesticide Monitoring Region (PMR) refers to an area of the state that contains similar land and water features and similar types of pesticide use practices. By dividing the state into regions, the MDA can provide information about the effects of pesticides in each unique area of the state. A map of the 10 PMRs is located in the "Geographical Coverage" section of this measure.

Private Well Monitoring Networks refer to groups of private well owners that agree to collect well water samples and submit them for nitrate analysis. The monitoring network is statistically designed for an unbiased sample collection.

Trend refers to a change, either an increase or decrease, in the frequency of detection or concentration of pesticides, nitrates or other water quality parameters in groundwater.

Volatile organic compounds are organic chemicals that have a low boiling point and evaporate readily.

Target

Groundwater is not assessed as impaired/unimpaired as is surface water since there are currently no water quality classifications for groundwater. Groundwater standards used in groundwater are the health-based guidance set by the Minnesota Department of Health to protect human health from contaminants in drinking water. The target is to show decreasing detection frequencies and/or concentrations of common detection pesticides, nitrate, chloride, and VOCs. For example, subsequent targets may be to decrease common detection pesticide concentration and frequency of detection over time or stabilize and decrease nitrate concentration trends. Subsequent actions and targets will be based on the trends found by these analyses.

Baseline

Pesticides

The baseline year for MDA's groundwater reporting is 2000 for Pesticide Monitoring Region (PMR) 4 and PMR 9, 2006 for PMRs 1, 6, 7 and 2007 for PMR 5.

Nitrates

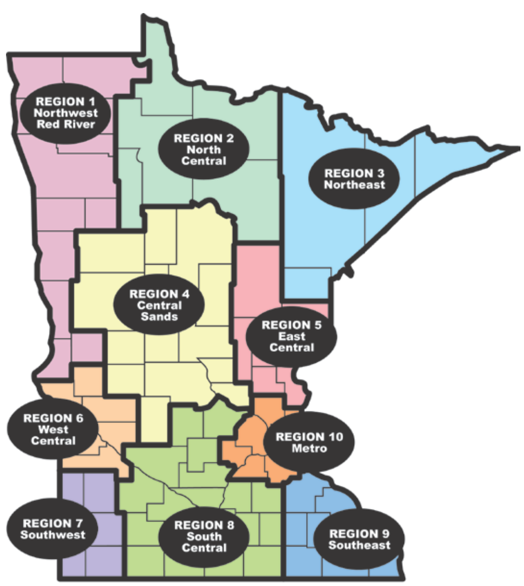
Central Sands Private Well Monitoring Network: baseline nitrate data collection began in spring 2011 in this region.
SE MN Monitoring Network: baseline nitrate data collection began in spring 2008 in this region.
Township Testing Program: began in fall 2013 and the initial sampling will continue for a period of approximately six years. The first round of sampling will provide a snapshot of nitrate conditions in each township. After the MDA receives all of the well testing results in a township, the data will be analyzed. The results of that analysis will determine the next steps. After six years, one time monitoring data should be available for the most vulnerable or sensitive townships in the state. The goal is to develop baseline information and to develop long-term trends in the most sensitive areas of the state.
The baseline for MPCA's ambient nitrate groundwater reporting is 2004, when the network was started. That network is currently being redesigned and will not be fully in place until 2014. The available 2004-2014 data will yield limited baseline information.

Chloride, Volatile Organic Compounds and Emerging contaminants

The baseline for MPCA's ambient groundwater reporting is 2004, when the network was started. That network is currently being redesigned and will not be fully in place until 2014. The available 2004-2014 data will yield limited baseline information.

Geographical Coverage

The MDA has established 10 Pesticide Monitoring Regions to provide a framework for conducting groundwater and surface water monitoring. The MDA's water quality monitoring efforts are statewide.



The MPCA's ambient groundwater network also is on a statewide scale.
The general geographic coverage for nitrates would be both statewide and focused on MDA's Pesticide Monitoring Regions. Local implementation projects will be based on the county or township scale. The Central Sands project includes 14 counties and is considered a regional network. Township-scale monitoring is on a smaller geographic scale.

Data and Methodology

Data Collection Methodology

Pesticides

Concentration trend graphics will be developed annually for common detection pesticide; frequency of detection, median, 75^{th} percentile and 90th percentile statistics. Graphs will be accompanied by a table of the results of calculations of general monotonic trend for each summary statistic. Trends will be calculated by use of the Mann-Kendall test or other appropriate statistical method. Magnitude of any trends present will be estimated using the Thiel-Sen method. Statistical methods may change in response to newly developed techniques or new applications of previously existing methods.

Nitrates

Trends in nitrate concentration (both MDA and MPCA) will be calculated by use of non-parametric tests or other appropriate statistical methods. For the MPCA's nitrate data, Mann-Kendall or Regional Kendall test are the most appropriate to use to determine concentration trends.
MDA monitoring unit sample collection: MDA staff collects groundwater samples two to four times annually.
Central Sands Private Well Network: Volunteers collect samples at least annually.
SE MN Monitoring Network: Volunteers will collect the samples at least annually.

Township Testing Program: Volunteers will collect one sample from the participating wells and MDA will conduct follow-up sampling of wells with elevated nitrate concentration. MDA plans to target water sample collection from approximately 70,000 private wells, in about 275 vulnerable townships, between 2013 and 2020.

Chloride, Volatile Organic Compounds and Endocrine Disruption Compounds

The key parameters to be tracked by MPCA will be calculated by non-parametric statistics, the Mann-Kendall or Regional Kendall test are the most appropriate to use to determine chloride concentration trends. Logistic regression is likely the most appropriate statistical test to use to determine whether the detections of VOCs or contaminants of emerging concern have changed over time.

Data Source

MDA's results are generated by the MDA analytical laboratory on groundwater samples and are maintained in a joint MPCA/MDA database, called EQuIS. The Township Testing Program nitrate data is generated by contract laboratories.

Most MPCA ambient groundwater data are generated by the Minnesota Department of Health (MDH) Environmental Laboratory. Contaminant of emerging concern data are generated by the US Geological Survey (USGS) laboratories, and PFC data are generated by AXYS laboratory. The data generated by the MDH laboratory are maintained in the joint MPCA/MDA database, called EQuIS. The data generated by the USGS and AXYS laboratory are expected to be migrated to EQuIS in 2013.

Private Well monitoring networks

Through 2017, there has been there is seven full years of data for the Central Sands private well monitoring network. The first round of sampling began in spring 2011.
The SE MN Monitoring Network has ten years of data since 2008.
The Township Testing Program began in 2013 and through 2016, wells in 167 townships in nineteen counties have been sampled.

Data Collection Period

Pesticides

The MDA's pesticide monitoring began January 2000 and is intended to be maintained in perpetuity.

Nitrates

The MDA groundwater monitoring program has been sampling nitrates since 1986 in edge of field conditions, which do not reflect general drinking water conditions. This is intended to continue in perpetuity.
Central Sands Private Well Monitoring Project: Began in March 2010 and will continue for at least a period of 20 years.
South East Minnesota Volunteer nitrate monitoring Network: Began in 2008 and there is no set end date.
Township Testing Program: Began in 2013 and should continue at least for a period of 20 years. The goal is to develop long-term trends in the most vulnerable townships in the state. It is important to note that this approach is bias to the most sensitive areas of the state and data collected will only be used to make conclusions about nitrate trends in drinking water in the townships sampled.
The MPCA's groundwater monitoring network began in 2004 and is intended to be maintained in perpetuity.

Chloride, Volatile Organic Compounds and Endocrine Disruption Compounds

The MPCA's groundwater monitoring network began in 2004 and is intended to be maintained in perpetuity.

Data Collection Frequency

MDA's samples are collected two to four times annually from specifically designed and installed monitoring wells, naturally occurring springs, and private drinking water wells. Sampling frequency depends on site location and hydrogeologic conditions.
Nitrate sampling in the private well networks occurs annually.
In the Township Testing Program, wells are sampled once with additional samples possibe if nitrates are detected in the initial sample. The additional samples may also include analysis for pesticides as part of the Private Well Pesticide Sampling Project.
The MPCA's groundwater monitoring wells are sampled annually.

Supporting Data Set

Pesticides

As of December 2015 MDA's groundwater pesticide data set consists of approximately 300,000 records of analyses conducted on approximately 4,250 groundwater samples.

Nitrates

The MDA has been monitoring well nitrate results starting in 1986. From 1986 to 1999, DNR and USGS observation wells were used for the monitoring program. These monitoring wells are edge of field conditions and do not reflect general drinking water conditions. A newly designed monitoring well network in the Central Sands region was completed and sampling commenced by early 2011. The Centrals Sands network was used as a model to develop the approach to township-scale private well monitoring networks that began in 2013.

The SE MN Monitoring Network data is being collected to monitor long term trends of nitrates in private wells. This program is ongoing. The data will be used to make conclusions about nitrate conditions in drinking water in the region and not by specific well.

Township Testing Program is ongoing and will provide a snapshot view of nitrate concentrations for the sampled townships. Over 70,000 private wells are targeted with this program, since the program is voluntary the actual number of samples will depend on the response rate in the given area. The data will only be used to make conclusions about nitrate conditions in drinking water in the townships sampled. Please note that the regional and township data sets are different.
Nitrate Clinics: From 1993-2006 MDA and its local partners held walk-in style nitrate clinics. These clinics were funded in part with Legislative Commission on Minnesota Resources (1997-1999), EPA 319 (1997-2000) and the MDA Fertilizer Account. These clinics were mainly designed as a public education tool and were not scientifically or statistically designed.

The MPCA presents no supporting data, as we have not yet begun to report on this measure.

Caveats and Limitations

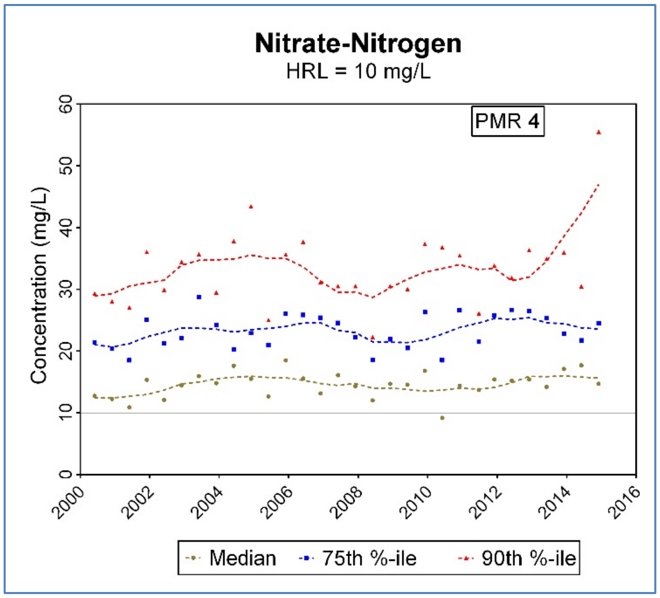
Pesticides

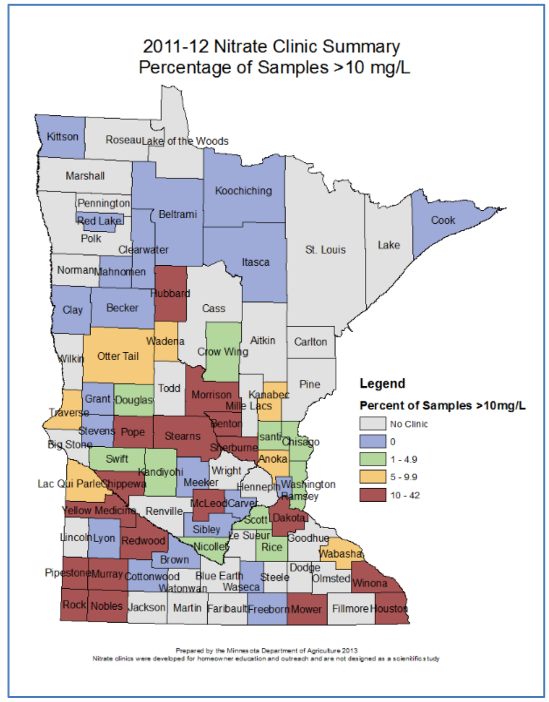
Data on pesticides in groundwater is considered complex data. The data is sometimes censored, contains variable detection limits, missing values, and unquantifiable detections. The data over time is typically non-linear, contains multiple chemicals, and has variability over time making analysis of results quite difficult. As a result of the complex data, graphical representations of the data will frequently display trends long before statistical analysis is capable of confirming a trend is present.

Nitrates

The data collected with the monitoring wells was designed to monitor pesticides at the most vulnerable parts of the aquifers, on the edge of fields. However, nitrate has been sampled along with the pesticide data.

The Central Sands and SE MN private well monitoring networks have been designed to sample the groundwater that people are drinking and may not be representative of all groundwater resources in the area. The same applies to the Township Testing program. The nitrate clinics were not statistically or scientifically designed and were used for educational purposes only. The nitrate clinic data may be a high estimate; it is not representative of all private well drinking water.





Chloride, Volatile Organic Compounds and Endocrine Disruption Compounds

The suite of VOCs and contaminants of emerging concern analyzed in the groundwater is censored at a variety of method reporting limits. These data will need to be re-censored at a common reporting limit to most accurately describe the most-frequently detected chemicals in the groundwater. Emerging contaminant concentrations below the method reporting limit are reported by the laboratory since the qualitative identification is done using mass spectrometry. These concentrations and those with matrix interferences or not meeting quality-assurance criteria are qualified. The emerging contaminants data often is affected by contamination from the laboratory and field. These data must be reviewed prior to analysis to ensure the reported concentrations are not an artifact of field or laboratory contamination.

Future Improvements

Laboratory capacity and capability is always the limiting factor in groundwater characterization regarding pesticide impacts. Analysis for pesticides in water is very expensive, collection of the samples is time consuming and analysis of the data is quite difficult. Measures to improve laboratory capacity and capability are continuously being sought and are normally very expensive, sometimes prohibitively so. The design and operation of the monitoring network(s) are continuously reviewed for improvements in efficiency, scientific and technical validity, and for newly emerging methods or insights from other organizations conducting similar work in other locations. The entire state cannot be comprehensively monitored at one time resulting in the need to stage various aspects of a complete monitoring system. Staging of program components is typically done as funding becomes available and may be short-term or one-time in nature and is used to begin, refine or extend a program element. Short term funding generally has very limited usefulness for trend monitoring in groundwater as trends are usually not evident for 5 years or more.

Develop more private well networks throughout the state in order to develop long-term trends.

Financial Considerations

Contributing Agencies and Funding Sources

Substantial funding for groundwater pesticide work comes from non-clean water funds. This also includes limited funds from the EPA.

Funding for water quality monitoring has come through the MDA, MDH, and MPCA.

Both the Central Sands Private Well and the SE MN monitoring networks are funded with Clean Water funds. The MDA is the lead agency in the Central Sands Private Well network and partners with the SEMNWRB for the SE MN monitoring network. Both projects are local implementation projects and partner with counties within each of the network areas.

Funding for the Township Testing Program is provided by the Clean Water Fund. It is also a local implememtation project and partners with counties and local Soil and Water Conservation Districts.

Measure Points of Contact

Agency Information

Minnesota Department of Agriculture:
Michael MacDonald
Hydrologist
Pesticide and Fertilizer Management Division
michael.macdonald@state.mn.us

Dan Stoddard
Division Director
Pesticide and Fertilizer Management Division
dan.stoddard@state.mn.us

Margaret Wagner
Supervisor
Clean Water Technical Assistance Unit
Pesticide and Fertilizer Management Division
margaret.wagner@state.mn.us

Minnesota Pollution Control Agency:
Paul Hoff
Supervisor
Environmental Reporting and Special Studies
paul.hoff@state.mn.us

Example summary table of time series pesticide groundwater monitoring information.

PMR 1	Median (µg/L) 05	06	07	08	09	10-1	10-2	75th Percentile (µg/L) 05	06	07	08	09	10-1	10-2
Metolachlor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor ESA	nd	-	nd	nd	nd	nd	nd	nd	-	nd	nd	nd	nd	nd
Metolachlor OXA	nd	-	nd	nd	nd	nd	nd	nd	-	nd	nd	nd	nd	nd
PMR 4														
Metolachlor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor ESA	0.23	0.20	0.22	0.19	0.15	0.1720	0.1720	1.13	1.24	1.72	1.14	1.27	1.465	1.465
Metolachlor OXA	nd	nd	nd	nd	nd	nd	nd	0.11	0.12	0.19	0.11	0.18	0.1667	0.1635
PMR 5														
Metolachlor	-	-	nd	nd	nd	nd	nd	-	-	nd	nd	nd	nd	nd
Metolachlor ESA	-	-	0.60	0.29	0.54	0.3320	0.3320	-	-	1.85	2.71	1.80	1.172	1.172
Metolachlor OXA	-	-	nd	nd	0.09	0.0284	nd	-	-	0.37	0.49	0.17	0.0490	nd
PMR 6														
Metolachlor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor ESA	nd	-	nd	nd	0.07	0.0536	nd	0.75	-	0.05	0.16	0.30	0.1900	0.1900
Metolachlor OXA	nd	-	nd	nd	nd	nd	nd	nd	-	nd	nd	nd	nd	nd
PMR 7														
Metolachlor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor ESA	1.09	-	0.12	0.08	0.09	0.1075	0.1075	1.21	-	0.65	0.39	0.56	0.3900	0.3900
Metolachlor OXA	0.05	-	nd	nd	nd	nd	nd	0.13	-	nd	nd	nd	0.0103	nd
PMR 8														
Metolachlor	-	nd	nd	nd	nd	nd	nd	-	nd	nd	nd	nd	nd	nd
Metolachlor ESA	-	-	nd	nd	0.22	0.2580	0.2580	-	-	nd	0.25	0.53	0.4597	0.4597
Metolachlor OXA	-	-	0.07	nd	nd	nd	nd	-	-	0.59	nd	nd	nd	nd
PMR 9														
Metolachlor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	P	P	P	P
Metolachlor ESA	0.13	0.24	0.27	0.53	0.52	0.4050	0.4050	0.26	0.84	0.81	1.21	0.79	0.8660	0.8660
Metolachlor OXA	nd	nd	nd	nd	nd	0.0153	nd	nd	nd	nd	0.07	nd	0.0441	nd
Urban														
Metolachlor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor ESA	nd	nd	nd	nd	nd	0.0112	nd	nd	nd	nd	nd	nd	0.0222	nd
Metolachlor OXA	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.0054	nd

PMR 1	90th Percentile (µg/L) 05	06	07	08	09	10-1	10-2	Maximum (µg/L) 05	06	07	08	09	10-1	10-2
Metolachlor	nd	nd	nd	nd	0.17	0.0710	0.0710	nd	nd	nd	nd	0.21	0.0800	0.0800
Metolachlor ESA	nd	-	nd	1.75	1.74	0.2406	0.2406	nd	-	nd	2.19	2.18	1.020	1.020
Metolachlor OXA	nd	-	nd	0.32	0.98	0.0613	0.0430	nd	-	nd	0.40	1.23	0.4300	0.4300
PMR 4														
Metolachlor	nd	nd	P	nd	nd	P	P	1.87	0.76	0.24	0.75	1.79	0.3700	0.3700
Metolachlor ESA	2.68	3.33	4.10	2.39	2.98	4.903	4.903	10.20	12.70	34.20	12.30	20.70	24.30	24.30
Metolachlor OXA	0.66	0.64	0.64	0.49	0.71	1.082	1.082	6.75	4.90	8.03	5.41	13.00	12.60	12.60
PMR 5														
Metolachlor	-	-	nd	nd	P	nd	nd	-	-	nd	nd	P	P	P
Metolachlor ESA	-	-	4.63	3.61	4.82	3.272	3.272	-	-	4.66	4.00	4.89	5.140	5.140
Metolachlor OXA	-	-	1.89	2.98	2.15	0.5950	0.5950	-	-	2.86	4.15	3.47	3.810	3.810
PMR 6														
Metolachlor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor ESA	0.76	-	0.49	0.38	0.75	0.4436	0.4436	0.76	-	0.67	0.47	0.81	0.5300	0.5300
Metolachlor OXA	nd	-	nd	nd	nd	nd	nd	nd	-	nd	nd	nd	0.0258	nd
PMR 7														
Metolachlor	nd	nd	P	nd	nd	P	P	nd	nd	P	nd	nd	P	P
Metolachlor ESA	1.23	-	1.08	0.62	0.89	0.8717	0.8717	1.23	-	1.16	0.65	0.94	0.9320	0.9320
Metolachlor OXA	0.15	-	0.07	nd	nd	0.0515	nd	0.15	-	0.09	nd	nd	0.0538	nd
PMR 8														
Metolachlor	-	P	nd	nd	nd	nd	nd	nd	P	nd	nd	nd	P	P
Metolachlor ESA	-	-	nd	0.51	0.97	0.6508	0.6508	0.12	nd	nd	0.89	1.43	1.760	1.760
Metolachlor OXA	-	-	2.00	0.02	0.02	0.0380	nd	nd	nd	2.69	0.07	0.07	0.0414	nd
PMR 9														
Metolachlor	P	P	P	P	0.17	0.0360	0.0360	P	0.58	P	0.12	5.00	4.250	4.250
Metolachlor ESA	0.36	1.48	1.26	1.70	1.48	1.680	1.680	0.43	3.13	2.60	2.70	3.63	4.550	4.550
Metolachlor OXA	nd	0.11	nd	0.14	0.15	0.2015	0.2015	nd	0.61	0.16	0.22	0.59	1.570	1.570
Urban														
Metolachlor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Metolachlor ESA	nd	0.11	0.61	0.40	0.26	0.1470	0.1470	nd	1.59	8.49	9.71	0.76	0.1470	0.1470
Metolachlor OXA	nd	nd	nd	nd	nd	0.0235	nd	0.07	nd	0.65	5.43	nd	0.0356	nd

Changes over time in source water quality used for community water systems

Measure Background

Visual Depiction

No specific visualization; measure will include a picture of a water tower without a city logo.

Measure Description

The Minnesota Department of Health (MDH) collected general water chemistry samples from community water systems from summer 2010 through the end of 2014. Systems can use their individual results to better understand the water quality from their unique aquifers and well depths or their surface waters, to assess and maintain water quality at entry points and within the distribution system, and as baseline data in evaluating potential contamination events. It is recommended that systems continue to regularly monitor for the water quality parameters reported by MDH.

Associated Terms and Phrases

Ammonia Nitrogen: Ammonia in water can decrease the efficiency of disinfection treatment. Oxidation of ammonia will result in the formation of nitrite.
Arsenic: Arsenic is a semi-metal element in the periodic table. It is odorless and tasteless. It enters drinking water supplies from natural deposits in the earth or from agricultural and industrial practices. The federal maximum contaminant level (MCL) for arsenic is 10 µg/l.
Barium and Strontium: Barium and strontium are minerals that naturally occur in water. They can be used as indicators of a water source (aquifer).
Bromide and Chloride: The ratio of bromide to chloride in water can be an indicator of potential effects of surface activities on ground water. Absolute values of these two compounds are not as significant as the ratio between the two minerals. Bromide and chloride can also be used to determine a water's source (aquifer).
Calcium and Magnesium: Calcium and magnesium are indicators of waters hardness. Knowing a water's hardness will help in optimizing the water treatment process.
Carbonate and Bicarbonate Alkalinity: Alkalinity is the measure of the ability of the water to neutralize acid. This can be useful in assessing and optimizing corrosion control treatment.

Community Water Systems (CWSs): Also known as community public water supplies, CWSs serve at least 25 persons or 15 service connections year-round, which includes municipalities, manufactured mobile home parks, etc. These systems are required to provide a safe and adequate supply of water under the federal Safe Drinking Water Act (SDWA). Currently there are almost 1,000 CWSs in Minnesota.

Conductivity: Conductivity measures water's ability to conduct electrical current. Conductivity can be an indicator of water quality and can also help in assessing TDS.
Dissolved Oxygen (DO): High dissolved oxygen concentrations can increase the corrosion process within the distribution system. This can lead to contaminants such as lead and copper being introduced into the water supply and also reduce the lifetime of distribution piping and household plumbing materials.
Entry point: The place where the source water (from a well or surface water) comes into the water treatment plant or water supply system. The term is used to describe where the water sample is collected. Sample results from the entry point provide a picture of the source water.

Fluoride: Fluoride can occur naturally in an aquifer's geology and is commonly added to drinking water to promote dental health of the consumers. The US EPA secondary standard for fluoride is 2 mg/L.
Heterotrophic Plate Count (HPC): HPC is an analytic method used to measure the variety of bacteria that are common in water. Heterotrophic bacteria occur in drinking water even after disinfection. Values greater than 500 CFU/mL may indicate poor microbiological quality. HPC greater than 10,000 CFU/mL can mask total coliform counts.
Iron and Manganese: Iron and manganese are metals that are commonly found in water. They are considered secondary contaminants. The federal secondary standard for iron and manganese are 0.3 mg/L and 0.05 mg/L respectively.
Metals Scan: The MDH Public Health Lab will do a metals scan to analyze for 67 different trace metals. The results are not accurate enough to indicate well-by-well or metal-by-metal water quality, but are expected to help broadly characterize chemistry in different hydrogeologic settings across Minnesota.
Nitrites: Nitrites are nitrogen-oxygen chemical units which combine with various organic and inorganic compounds. The federal MCL for nitrite is 1 mg/L.
Oxidation Reduction Potential (ORP): Oxidation Reduction Potential, also known as Redox, is the activity or strength of oxidizers and reducers in relation to their concentration. ORP is also affected by pH.
pH: pH is a measure of how acidic or alkaline water is. pH is important in assessing water quality and the speciation of compounds in water. pH can also be an indicator of the corrosiveness of water and plays a key role in assessing corrosion control treatments.
Potassium and Sodium: Potassium and sodium can be naturally occurring in water or the result of chemicals being added to water during the treatment process. Although potassium and sodium may cause some health effects in susceptible individuals, potassium and sodium intake from drinking water is below the level at which adverse health effects may occur in healthy individuals.
Sulfate: Sulfate is considered a secondary contaminant by the US EPA. The federal secondary standard for sulfate is 250 mg/L, the level at which taste and odor issues can occur.
Temperature: Temperature can affect water chemistry and water quality.
Total Dissolved Solids (TDS): Total dissolved solids are the compounds in water that cannot be removed through conventional filtration. TDS are made up of compounds which dissociate in water to form ions. TDS is considered by US EPA to be a secondary contaminant, with a secondary standard of 500 µg/L, the level at which taste and laxative properties can occur.
Total Organic Carbon (TOC): Total Organic Carbon is the measure of all organic carbon molecules in water. TOC can react with disinfectants to produce disinfection byproducts in the distribution system.
Total Phosphorus: Total phosphorus is the total measure of phosphorus in water. Phosphorus is often added to drinking water in the form of phosphates to sequester iron and manganese and also as a corrosion control method.

Target

MDH conducted sampling at 2,300 community water system wells and a number of surface water sources.

Baseline

Similar parameters were included in the MDH Public Water Supply Data hardcopy books published in 1989. These data, along with the results from this period of sampling (2010-2014), serve as the baseline data set for future monitoring.

Geographical Coverage

The measure is statewide.

Data and Methodology

Methodology for Measure Calculation

Water quality analysis was done in the field and at the MDH Public Health Laboratory.

Data Source

The data is held in the Minnesota Drinking Water Information System (MNDWIS) in the MDH Drinking Water Protection Section.

Data Collection Period

Samples were collected from 2010-2014.

Data Collection Methodology and Frequency

Each community public water system's drinking water source(s), water system entry point(s), and water distribution system was sampled by MDH for:

- Ammonia Nitrogen
- Total Phosphorus
- Total Organic Carbon
- Total Alkalinity
- Carbonate Alkalinity
- Bicarbonate Alkalinity
- Dissolved Oxygen
- Conductivity
- Total Dissolved Solids
- Oxidation Reduction Potential
- Temperature
- pH

MDH provided additional results from drinking water sources for:

- Arsenic
- Barium
- Bromide and Chloride
- Calcium
- Iron
- Potassium
- Sodium
- Sulfate
- Nitrite
- Magnesium
- Manganese
- Strontium

If water treatment involves more than chemical addition, MDH also provided results at water system entry points for:

- Calcium
- Iron
- Magnesium
- Manganese
- Nitrate+Nitrite
- Nitrite

Supporting Data Set

The complete data set is available from MDH by request.

Caveats and Limitations

Water quality at the source, entry point, and distribution system is variable, and that variability was not captured by the results of MDH's 2010-2014 study. Additionally, community water systems are not randomly distributed across the state; the results of this study do not necessarily represent an unbiased snapshot of the state's source water quality.

Future Improvements

It is proposed to conduct rounds of general water chemistry sampling at ten-year intervals.

Financial Considerations

Contributing Agencies and Funding Sources

Total general water chemistry sampling costs for 2010 through 2014 was approximately $1 million. Although this measure helps us evaluate the impact of activities supported by the Clean Water Fund, this study was supported by Safe Drinking Water Fees, not by Clean Water Fund dollars.

Communication Strategy

Target Audience

The target audience for these water quality results includes, but is not limited to, community water systems, consulting engineers, academia, and the general public.

Associated Messages

MDH recommends systems regularly monitor for the above-listed water quality parameters and use the data as a tool to assess and maintain water quality throughout the water system. Results will be used as a starting point for evaluating systems' needs related to source water, treatment, distribution, and storage.

Other Measure Connections

Community water systems in Minnesota rely on both surface water and groundwater sources. The results of this measure may be examined in conjunction with other measures documenting surface water and groundwater quality.

Outreach Format

Information from the study will be provided on the MDH website.

Measure Points of Contact

Agency Information

Karla Peterson, Community Public Water Supply Unit Supervisor, Drinking Water Protection Section, Minnesota Department of Health: karla.peterson@state.mn.us

Nitrate and arsenic concentrations in newly constructed wells

Measure Background

Visual Depiction

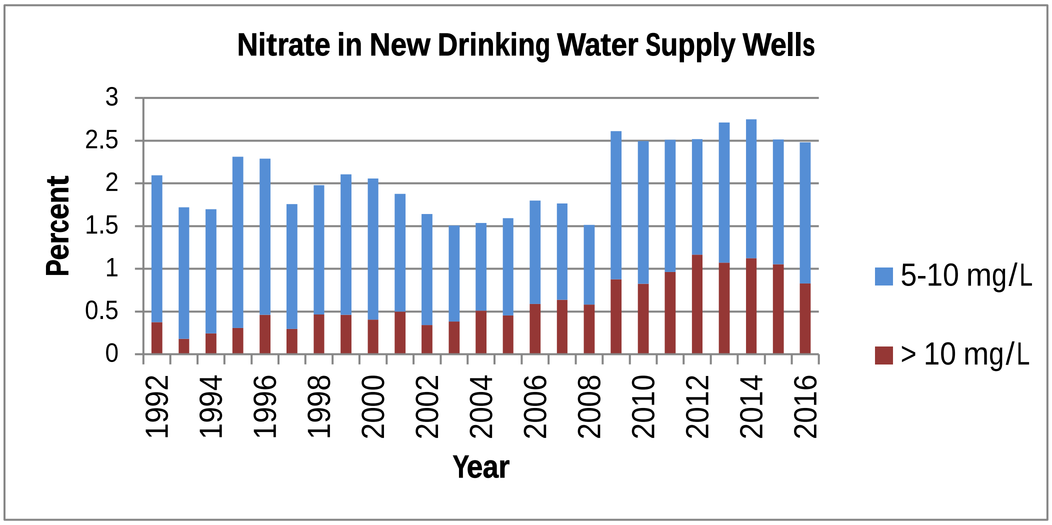


Figure 1: Nitrate in New Drinking Water Supply Wells (1992-2016)

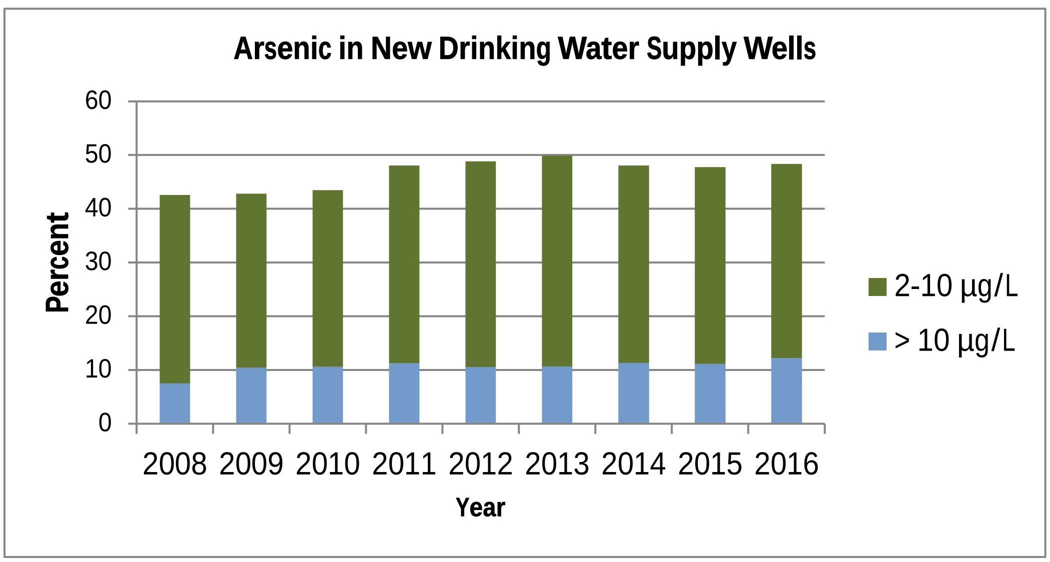


Figure 2: Arsenic in New Drinking Water Supply Wells (2008-2016)

Measure Description

This measure tracks the percentage of newly constructed drinking water supply wells with elevated nitrate concentrations. Natural levels of nitrate are typically quite low (below 3 milligrams per liter [mg/L]). Elevated nitrate concentrations in drinking water wells are associated with sources such as fertilizers, animal wastes, or human sewage. Minnesota statute and rules governing the location and construction of wells (Minnesota Statute 103I and Minnesota Rules 4725) are intended to avoid elevated nitrate in groundwater. In addition, activities to manage nitrate sources can result in a reduction of nitrate input into groundwater. Therefore, this is a measure of both the effectiveness of the well code and nitrate management activities.

This measure also tracks the percentage of newly constructed drinking water supply wells with arsenic detections. Arsenic occurs naturally in rocks and soil across Minnesota and can dissolve into groundwater. Because of the complex nature of arsenic occurrence, it is very difficult, and in some cases impossible, to avoid arsenic when constructing a new well. Clean Water Funds are being used to better understand the occurrence of arsenic in order to help well contractors avoid constructing wells with high levels of arsenic if possible.

Associated Terms and Phrases

Nitrate: A compound of nitrogen and oxygen (NO_3) found in nature and in many food items in the human diet and also has many human-made sources. Consuming too much nitrate can affect how blood carries oxygen and can cause methemoglobinemia (also known as blue baby syndrome). Bottle-fed babies under six months old are at the highest risk of getting methemoglobinemia.

Arsenic: An element that occurs naturally in rocks and soil across Minnesota; small amounts can dissolve into groundwater that may be used for drinking water. Drinking water with arsenic in it can increase the risk of cancer and other serious health effects.

Methemoglobinemia: A blood disorder that affects how blood carries oxygen, can cause skin to turn a bluish color, and can result in serious illness or death. Consuming too much nitrate can cause methemoglobinemia; bottle-fed infants under six months old are at the highest risk of getting methemoglobinemia from drinking water with elevated concentrations of nitrate.

Drinking water supply well: A well that provides water used for a potable (drinking, cooking, bathing, washing, etc.) supply. This includes both public and private water supply wells.

Drinking water standard: The amount of a substance allowed in public water systems. The drinking water standard for nitrate is 10 mg/L. The drinking water standard for arsenic is 10 micrograms per liter (µg/L).

Target

For nitrate: A downward trend in the percent of new drinking water supply wells with nitrate exceeding the drinking water standard (10 mg/L) is the target.

For arsenic: A downward trend in the percent of new drinking water supply wells with arsenic detections (2 µg/L is the usual detection limit).

Baseline

For nitrate: The historical percentage of new drinking water supply wells exceeding the drinking water standard (10 mg/L) will serve as the baseline.

For arsenic: The historical percentage of new drinking water supply wells with arsenic detections will serve as the baseline.

Geographical Coverage

Statewide

Data and Methodology

Methodology for Measure Calculation

For nitrate: The number of new drinking water supply wells with nitrate above the drinking water standard will be compared to the total number of new wells constructed each year as reported to the Minnesota Department of Health (MDH).

For arsenic: The number of new drinking water supply wells with arsenic detections will be compared to the total number of new wells constructed each year as reported to MDH.

Data Source

Every new drinking water supply well in the state is required to be sampled for nitrate and arsenic prior to putting the well into service. The results of the analysis are required to be submitted to MDH and to the well owner. This information is entered into MDH's "Wells" database which is managed by the MDH Well Management Section.

Data Collection Period

Nitrate: 1992 to present.
Arsenic: 2008 to present.

Data Collection Methodology and Frequency

After well construction is completed, a water sample is collected from the well and submitted to an MDH certified laboratory for analysis. There is no requirement for follow up sampling. Sample results are required to be submitted to MDH. The analysis will be conducted annually for the calendar year.

Supporting Data Set

Year	Greater than 10 mg/L	Between 5 and 10 mg/L
1992	0.38	1.72
1993	0.18	1.54
1994	0.24	1.45
1995	0.31	2.01
1996	0.46	1.82
1997	0.30	1.46
1998	0.47	1.51
1999	0.46	1.64
2000	0.40	1.65
2001	0.50	1.38
2002	0.34	1.30
2003	0.38	1.12
2004	0.51	1.03
2005	0.45	1.14
2006	0.59	1.21
2007	0.64	1.13
2008	0.58	0.93
2009	0.88	1.73
2010	0.82	1.67
2011	0.96	1.55
2012	1.16	1.35
2013	1.07	1.64
2014	1.12	1.63

2015	1.05	1.46
2016	0.83	1.65

Figure 3: Percent of New Water Supply Wells with Elevated Nitrate

Year	Greater than 10 µg/L	Between 2 and 10 µg/L
2008	7.49	35.08
2009	10.41	32.41
2010	10.62	32.86
2011	11.26	36.82
2012	10.52	38.34
2013	10.63	39.30
2014	11.28	36.75
2015	11.12	36.66
2016	12.19	36.20

Figure 4: Percent of New Water Supply Wells with Arsenic Detections

Caveats and Limitations

Well construction is not uniformly distributed across the state. Nitrate concentrations can vary spatially and temporally depending on geology, land use, groundwater flow etc. Likewise, arsenic concentrations can vary based on the geology and well depth. The number of wells constructed varies from year to year.

Future Improvements

No improvements planned at this time.

Financial Considerations

Contributing Agencies and Funding Sources

The Well Management Section is funded nearly exclusively through fees on the construction and sealing of wells and borings. The funding for this measure will come from these fees. The cost for construction of wells and analysis of nitrate and arsenic is the responsibility of the well owner.

Communication Strategy

Target Audience

Audiences include people who get their drinking water from a private well, well contractors, local public health and environmental services, water testing laboratories, and other public health advocates (state and federal agencies, local businesses, and medical professionals).

Associated Messages

- Health risks presented by nitrate and arsenic in drinking water.
- How often nitrate or arsenic is found in a specific area of the state.
- Ways to reduce exposure to nitrate and arsenic in drinking water.
- Ways to reduce the likelihood of nitrate or arsenic being in private drinking water supply well water.

Outreach Format
Information regarding this measure is communicated via a program website, brochures, letters and magnets to private well owners, continuing education for licensed well contractors, working through local partners (local public health and environmental services, water testing laboratories, and local health professionals), and presentations at conferences and other events.

Other Measure Connections
This measure is connected with the following measure: “Changes over time in pesticides, nitrates and other key water quality parameters in groundwater” in that both are monitoring the concentrations of nitrate in groundwater.

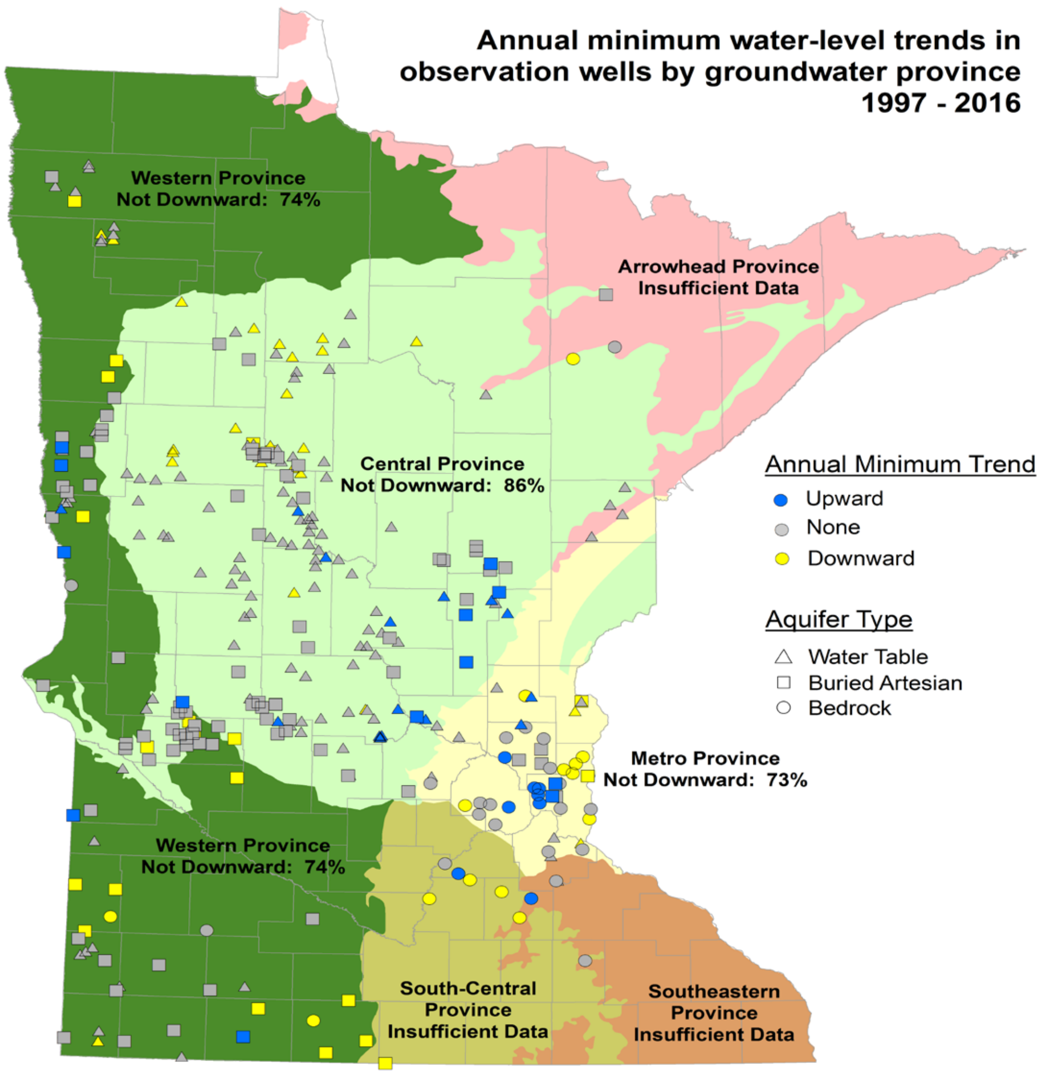
Measure Points of Contact

Agency Information
Chris Elvrum, Manager, Well Management, Environmental Health, Minnesota Department of Health
651.201.4598, chris.elvrum@state.mn.us

Changes over time in groundwater levels

Measure Background

Visual Depiction



Measure Description

Minnesota Department of Natural Resources (DNR) manages a statewide network of water-level observation wells. Data from these wells are used to determine long-term trends, interpret impacts of pumping and climate, plan for water conservation, and otherwise manage the water resource. Soil and Water Conservation Districts under contract with DNR measure the wells and report the readings to DNR. Monthly measurements are typically made from April through November for these wells. DNR has installed automatic data recorders in some observation wells. A set of indicator wells having at least 20 years of measurement records, distributed geographically across the state and in major aquifers used for water supplies, are tracked in monthly Hydrologic Conditions Reports. These indicator observation wells can be used to illustrate trends in groundwater levels around the state relative to the long-term records.

Associated Terms and Phrases

Aquifer Type: There are many aquifers with varying characteristics in Minnesota. Aquifers measured by observation wells are sorted into three categories. Water-table aquifers are typically shallow, contain the water table, and are generally well connected to the land surface. Buried Artesian aquifers are composed of unconsolidated sediments (i.e. sand and gravel) overlain by lower permeability sediments such as glacial till or lake clay that slow or restrict the vertical movement of groundwater. Bedrock aquifers include all aquifers composed of consolidated rocks.

Groundwater Provinces: Six regions of the state divided by the types and properties of aquifers in each province that affect the potential availability of groundwater, as defined by DNR. Minnesota Department of Health occasionally subdivides the Western and Central provinces into multiple provinces.

Indicator Well: Well used to evaluate aquifer level trend statistics for this measure. To qualify as an indicator well, it must have a minimum of nineteen (19) years of record with relatively few missing data, be geographically distributed across the state, and represent one of the major aquifers of the state. The number of aquifers with trend information is currently inadequate to meet the needs of the state, and the number will be increased in part with support from Clean Water Fund. As groundwater level monitoring wells are added and trends are determined, they will be added to this set of indicator wells.

Observation Well: A well or environmental borehole used for the purpose of measuring groundwater levels. May be referred to as an ‘ob well’ or ‘monitoring well’.

Trend: Groundwater level trends for each groundwater province were determined by calculating the percentage of downward trends in that province, determined for each indicator well in the province. In each groundwater province, the trend was defined as upward, downward, none, or insufficient data. For each indicator well, the Mann-Kendall test for monotonic trend was performed on the annual minimum of measurements for each year in the period of record. A trend was declared significant if the probability of obtaining the test statistic under no actual trend (p-value) was less than or equal to 0.05. The linear slope was calculated using the non-parametric Kendall-Theil robust line[1].

Target

Specific targets for groundwater levels are not defined. A range of groundwater levels are expected due to climatic variations and levels are specific to each location. A downward trend in groundwater levels by itself does not necessarily indicate unsustainable groundwater use. Water levels measured in observation wells can be combined with local information on climate, hydrogeology, land use, and water use to assess groundwater availability changes and sustainability.

Baseline

The baseline for comparing groundwater levels is the twenty year period 1997-2016.

Geographical Coverage

The measure is statewide.

Data and Methodology

Methodology for Measure Calculation

The Minnesota Department of Natural Resources observation well network has 341 wells with over nineteen (19) years of data, and they were selected for trend testing. The bulk of the wells had over twenty (20) years of data, but some wells did have up to two (2) years of missing data. This includes wells that had slow slug tests; although the data from these were deemed usable. Note: the 2012 analysis included 296 wells; an additional 45 wells now have the required 20-years of record and were added to the analysis.

The Mann-Kendall test for monotonic trend (e.g. Helsel and Hirsch[1]) was performed on the annual minimum of measurements for each year in the period of record. A trend was declared significant if the probability of obtaining the test statistic under no actual trend (p-value) was less than or equal to 0.05. For sufficiently long data sets, a p-value meeting this significance criterion may result even for a very low slope of the trend. Therefore, only data sets meeting the significance test and having a linear slope greater than or equal to 0.05 feet/year (1 foot per 20 years) were regarded as having a significant trend. The linear slope was calculated using the non-parametric Kendall-Theil robust line[1].

The period of record for indicator wells varies from 19 to 67 years. Data from the period 1997 through 2016 were used in the analysis. Annual minima were not calculated for years with few measurements or partial records that likely did not include a measurement close in value to the April through November minimum. Periods preceding a data gap greater than two years were excluded from the trend analysis. Because the significance test value is only correct if individual measurements are independent (not serially correlated), the records initially showing a trend were adjusted to remove serial correlation that is common in groundwater-level data. The trend-free pre-whitening procedure of Yue et al.[2] was used to make these adjustments to verify the significance of the trends.

Data Source

Water-level data are stored in an observation-well database maintained by the Minnesota Department of Natural Resources Ecological and Water Resources Division and provided on their website. Over the coming year, these data will be migrated to the State Cooperative Water Data System (Hydstra) and a new web interface will be developed. Old data is still available from the current site at http://climate.umn.edu/ground_water_level/.

Data Collection Period

Groundwater level data from 1997 to 2016 are used to calculate this measure.

Data Collection Methodology and Frequency

Data are collected at groundwater observation wells on a monthly or more frequent basis from April through November. Measurements are made at some wells during the other months of the year. Methods used to collect data range from manual measurements using a steel tape to automated pressure sensors/data recorders with quarterly manual measurement verification.

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[1] Helsel, D.R. and Hirsch, R.M. (2002) *Statistical Methods in Water Resources*, Techniques of Water Resources Investigations of the United States Geological Survey: Book 4, Hydrologic Analysis and Interpretation, Chapter A3, 510 p.

[2] Yue, S., Pilon, P., Phinney, R., and Cavadias, G. (2002) The influence of autocorrelation on the ability to detect trend in hydrological series, *Hydrological Processes* 16, 1807-1829.

Supporting Data Set

The data used to support this measure may be found online at http://climate.umn.edu/ground_water_level/.

Caveats and Limitations

This measure uses data from a limited number of observation wells around the state that are not generally representative of groundwater conditions at other locations. The method does not resolve the type of change in water-level over the analysis period, such as "step" changes over a shorter period of time versus longer-term or gradual changes. This measure also only considers annual minimum water levels without considering other aspects of seasonal groundwater-level fluctuations

Future Improvements

As the observation-well network is expanded and historical records at existing observation wells become longer, this measure will be reported for a larger number of measurement locations.

Financial Considerations

Contributing Agencies and Funding Sources

The Minnesota Department of Natural Resources groundwater-level monitoring program is funded by a mix of Clean Water Fund, bonding, and the General Fund. Observation-well construction costs have been supported by designated bonding funds. Clean Water Fund money also supports planning and maintenance of the observation-well network and program coordination.

Communication Strategy

Target Audience

The target audience for these groundwater-level conditions includes, but is not limited to, community public water systems, well drillers, community water-management planners, consulting engineers, academia, policy makers, and the general public.

Associated Messages

In addition to the application of observation-well data to DNR water resource management decisions, public and private well owners and their consultants use observation-well data to assess the need for well maintenance, in water-supply planning, and in assessing impacts of groundwater withdrawals to connected surface waters.

Other Measure Connections

The results of this measure may be examined in conjunction with other measures documenting climatic variations, land-use changes, and surface-water and groundwater quantity. Changes in relative groundwater levels may be correlated to changes in climate, groundwater use, and/or land use.

Outreach Format

Information regarding groundwater levels is provided on the Minnesota Department of Natural Resources website.

Measure Points of Contact

Agency Information

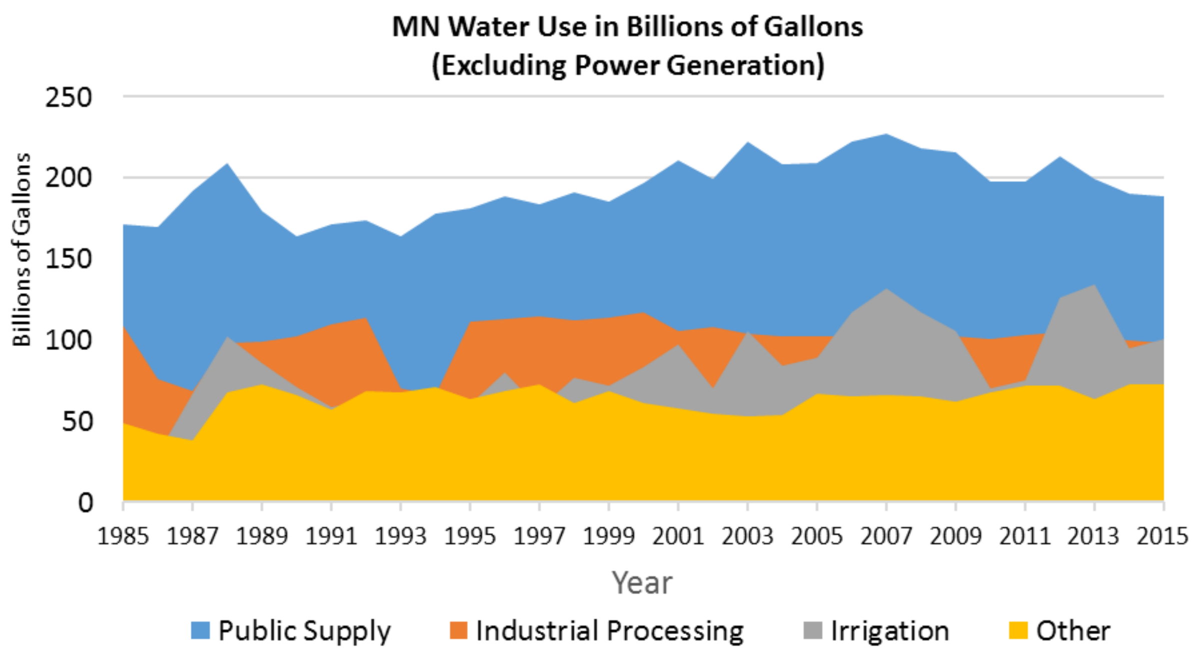
Greg Kruse
Water Monitoring and Surveys Unit Supervisor
Minnesota Department of Natural Resources
Division of Ecological and Water Resources
greg.kruse@state.mn.us

Jay Frischman
Groundwater and Hydrogeology Unit Supervisor
Minnesota Department of Natural Resources
Division of Ecological and Water Resources
jay.frischman@state.mn.us

Water Efficiency: changes in total and per capita water use

Measure Background
This measure describes how much water (groundwater and surface water) is used in Minnesota – as an annual statewide total and per person.

Visual Depiction
The graphic depicts Minnesota's water use in billions of gallons per year (excluding power generation).



Measure Description
The measure communicates how water use varies from year to year by major category and per person. Reported categories include public supply, industrial processing, irrigation and other.

Associated Terms and Phrases
1. **MDNR** – Minnesota Department of Natural Resources
2. **Industrial Processing** - Water used in mining activities, paper mill operations, food processing. Three-fourths or more of withdrawals are from surface water sources.
3. **Irrigation** - Water withdrawn from both surface water and groundwater sources for agricultural crop and non-crop uses. All irrigation is considered consumptive.
4. **Other** - Water withdrawn for activities including air conditioning, construction dewatering, water level maintenance, and pollution confinement.
5. **Power Generation** - Water used for cooling at electrical power generating plants. This is historically the category with the largest water use volume and relies almost entirely on surface

water sources. Power Generation use is primarily non-consumptive, in that most of the water withdrawn is returned to its original source.

6. **Public Water Supply** - Water distributed by community suppliers for domestic, commercial, industrial, and public users. The category relies on both surface and groundwater sources.

Targets

There are a variety of statewide and local targets for this measure. Various water efficiency targets, established since the Clean Water, Land and Legacy constitutional amendment was passed, are listed below.

For example, MDNR includes the following in the local water supply plan template for public water suppliers:

- Unaccounted water loss < 10%
- Residential water use < 75 gallons/person/day
- At least 1.5% reduction in institutional, industrial, commercial, and agricultural water use over 10 years
- Decreasing trend in total per capita water use
- Maximum daily use vs. average daily use < 2.6

In the Twin Cities metropolitan area, the Metropolitan Council has identified a regional target of 90 gallons per person per day, on average, for *community* water systems.

Baseline

FY 2010 serves as the baseline for this measure.

Geographical Coverage

Statewide

Data and Methodology

Methodology for Measure Calculation

This measure is based on data provided by water appropriation permit holders to Minnesota Department of Natural Resources and by population estimates developed by the MN State Demographic Center.

Gallons of water per person per day was calculated by dividing total annual water use (all use categories, including power generation) by the total population in Minnesota in that year. This represents the average amount of water used per person for all purposes state.

Year	Total MN Water Use (Gal/Day)	Total MN Population	Gallons per person per day
2010	3,704,591,268	5,303,925	698
2012	3,682,228,800	5,368,972	685
2014	3,474,456,459	5,453,218	637
2016	3,372,221,158	5,528,630	609

Annual water use was also reported in major categories (public water supply, industrial processing, irrigation, and other). Water used for power generation was not included.

Year	Public Supply	Industrial Processing	Irrigation	Other
1985	171	109	49	49

1986	170	76	30	42
1987	192	69	67	38
1988	209	98	102	68
1989	180	99	86	73
1990	164	102	71	66
1991	171	110	59	57
1992	174	114	63	69
1993	164	70	30	68
1994	178	66	58	71
1995	181	111	60	64
1996	189	113	80	69
1997	184	115	58	73
1998	191	112	77	61
1999	185	114	72	69
2000	197	117	83	61
2001	211	106	97	58
2002	199	108	70	55
2003	222	104	106	53
2004	208	102	84	54
2005	209	102	89	67
2006	222	102	117	65
2007	227	103	132	66
2008	218	102	117	65
2009	216	102	106	62
2010	198	101	70	68
2011	198	103	75	72
2012	213	105	126	72
2013	199	102	134	64
2014	190	100	95	73
2015	189	98	101	73

Data Sources

- Minnesota Department of Natural Resources Water Use Data 1988-2016: http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html
- Minnesota State Demographic Center PopFinder for Minnesota, Counties & Regions: https://mn.gov/admin/demography/data-by-topic/population-data/our-estimates/pop-finder1.jsp

Data Collection Period

Data is available for 1988-2016. Data used to calculate water use per person focuses on 2010 – 2016.

Data Collection Methodology and Frequency

Water Use

Water use is reported to the MN Department of Natural Resources by water appropriation permit holders on an annual basis.

A water use (appropriation) permit from DNR Waters is required for all users withdrawing more than 10,000 gallons of water per day or 1 million gallons per year. However, there are several exemptions to water appropriation permit requirements:

- domestic uses serving less than 25 persons for general residential purposes,
- test pumping of a ground water source,
- reuse of water already authorized by a permit (e.g., water purchased from a municipal water system), or
- certain agricultural drainage systems (check with your area hydrologist for applicability).

Data are stored in the Minnesota Department of Natural Resources Permit and Reporting System (MPARS).

Population

In between the decennial census years, the State Demographic Center produces population and household estimates for Minnesota and its counties and communities. The latest estimates, for 2016, were released in July 2017. The initial base for the estimates is the most recent decennial census. The first step of the estimation process is to update the most recent estimates with any boundary changes in the past year involving population and households. The primary input for the estimates is building permit data for the year preceding the estimate. For areas not covered by building permits, homestead data from the Minnesota Department of Revenue are used. Available electric utility data, births and deaths are also used to evaluate the estimates. Counts for large group quarters such as college dormitories, prisons, jails and regional treatment centers are also collected each year. Data are available on the PopFinder website.

Supporting Data Sets

- NA

Caveats and Limitations

Water Use

Water use reporting is done by many different water appropriation permittees who use different measurement methods and reporting categories. In addition, not all water use requires a water appropriation permit and may not be accounted for. For example, there are several exemptions to water appropriation permit requirements:

- domestic uses serving less than 25 persons for general residential purposes,
- test pumping of a ground water source,
- reuse of water already authorized by a permit (e.g., water purchased from a municipal water system), or
- certain agricultural drainage systems (check with your area hydrologist for applicability).

In addition, continued tracking is needed to determine the amount of impact from annual difference in weather versus changes in management.

Population

The Minnesota State Demographic Center does not smooth the previously published estimates after each decennial census count. Therefore, data users may see a jump between 2009 and 2010, or 1999 and 2000, that is not a true population change. It is simply a case in which our estimate was corrected slightly by the census count. The best data is used to make these estimates, but occasionally the estimates are a bit further from the on-the-ground reality.

Future Improvements

With the creation of a new conservation tracker, DNR will have improved data about changes in water efficiency.

Communication Strategy

Target Audience

Stakeholders with interest in this measure include the State legislature, the Clean Water Council, and state agency partners.

Associated Messages

As Minnesotans, we get much more from our water than drinking and washing. Water also helps to provide power, irrigate crops, run industrial processes, and support our state's rich natural environment. And every drop of water that people move from one place to another for a variety of uses comes with a cost – such as the energy to move it, the infrastructure to treat it, and the impact to the source it was taken from.

Being good stewards means getting the most value out of the water we use, taking care not to waste it, and putting it back into the environment sustainably.

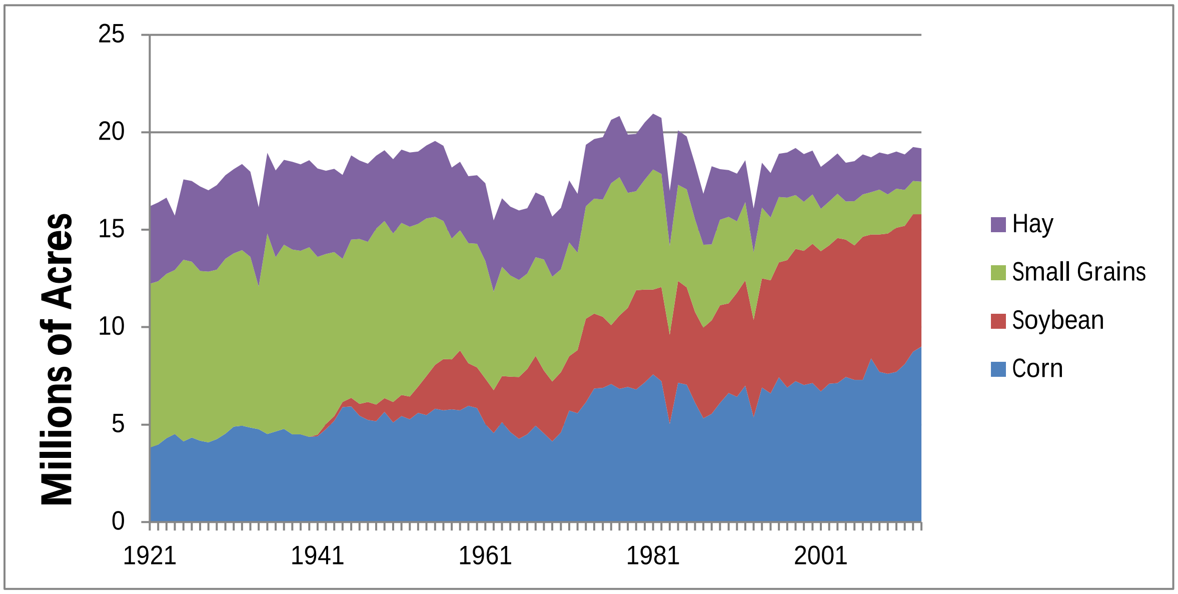
Measure Point of Contact

- Lanya Ross, Environmental Analyst – Water Supply Planning, Metropolitan Council
  Lanya.Ross@metc.state.mn.us
- Julie Ekman, Section Manager - Conservation Assistance and Regulations, Minnesota Department of Natural Resources
  Julie.Ekman@state.mn.us

External Drivers

Land-Use Changes – Agricultural Land Use

Measure Background



Measure Description

Agriculture is the second-largest industry in Minnesota, creating jobs, generating business and supporting other industries. Agricultural production may require the input of fertilizer or the removal/addition of water to increase food, fiber, feed and fuel production for consumption by humans and livestock. In addition, based on the type of crop produced and the management practices employed, there may be periods where agricultural lands are free or largely free of vegetation cover that normally reduces erosion potential. Finally, when livestock are produced, the volume of wastes produced and their concentration can increase substantially. For all these reasons, understanding major trends to agricultural land-use, both at the statewide and regional scales, is important for understanding what clean water restoration and protection strategies are being implemented and in evaluating their effectiveness.

Associated Terms and Phrases

None

Target

Minnesota has no targets for how agricultural lands are used. State and federal farm policies create incentives that may encourage certain types of agricultural land use, the adoption specific production practices, or to discontinuation of production and enrollment in land set-aside programs.

Baseline

There is no baseline associated with this measure, change over time on the land area devoted to specific types of crops are tracked.

Geographical Coverage

The approximately one-half of Minnesota devoted to agriculture production

Data and Methodology

Methodology for Measure Calculation

The USDA's National Agricultural Statistics Service (NASS) conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture. Production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use, and changes in the demographics of U.S. producers are only a few examples.

The NASS data shown were compiled by the Minnesota Department of Agriculture

Data Collection Period

The National Agriculture Statistics Services has been collecting data for the last 90 years. This measure tracks how major agricultural land-use activities have changed since 1920.

Data Collection Methodology and Frequency

The specific data set used in the 2018 Clean Water Fund Performance Report was compiled by the Minnesota Department of Agriculture and was obtained from the National Agricultural Statistics Service (NASS) by doing a query of MN historic crop data. See http://quickstats.nass.usda.gov/ for more information.

For more detail regarding NASS procedures for gathering & compiling this data see http://www.nass.usda.gov/About_NASS/index.asp.

Other Measure Connections

Agriculture land use is one of three land-use changes being tracked to examine how external drivers may impact Minnesota's ability to achieve its Clean Water and Drinking Waters goals and is meant to be viewed in concert with measures in the population change and climate change categories. Tracking external drivers will also help Clean Water partners adapt their actions over time, enhancing water quality and drinking water outcomes

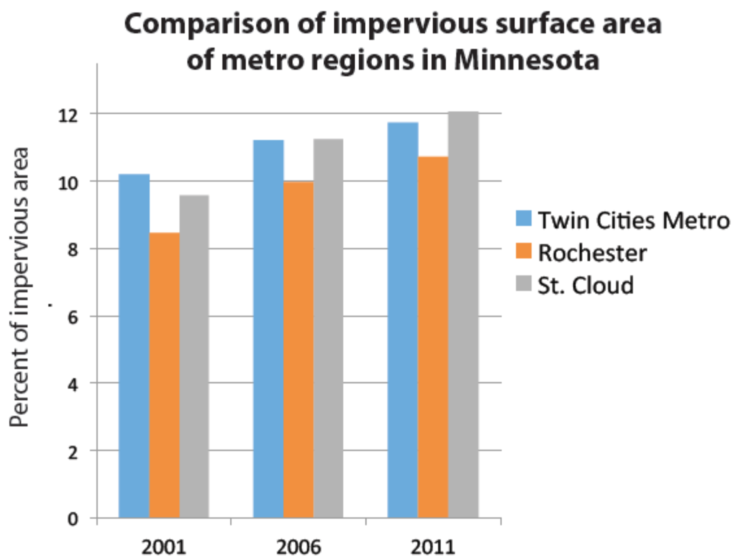
Measure Point of Contact

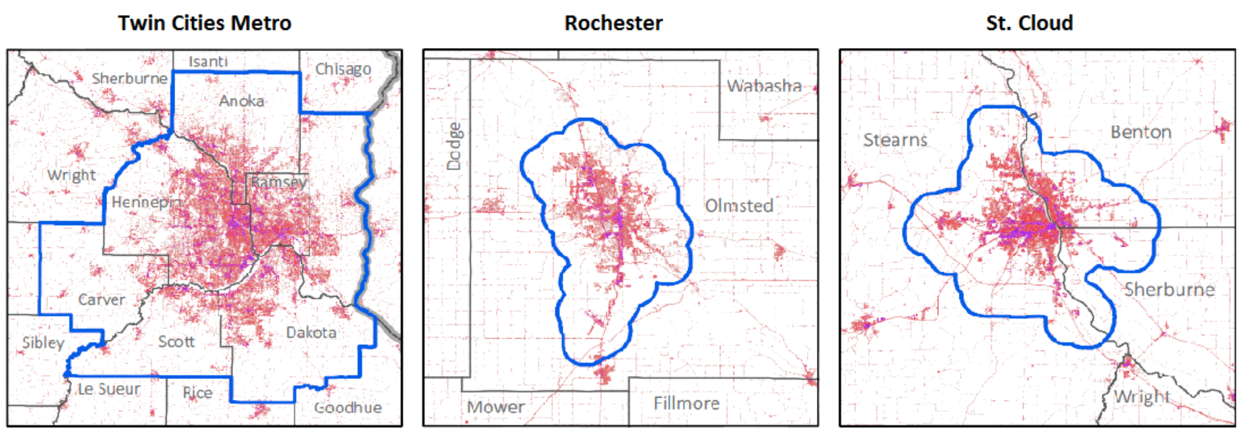
Agency Information

Jeffery Berg
MN Department of Agriculture
Pesticide & Fertilizer Management Division
625 Robert Street North
St. Paul, MN 55155-2538
jeffery.berg@state.mn.us

Land-Use Changes – Impervious Surface Coverage

Measure Background





Urban area analysis boundaries used to calculate percent impervious area.

Measure Description

Although on a statewide scale, the amount of impervious surface is a small fraction of the state's land area, it may be a large and highly significant percentage in locations dominated by urban, suburban, industrial, and/or transportation-related land uses. In addition, because rainfall or melting snow do not soak into these surfaces, they have a disproportionate potential to increase the amount of surface runoff and the speed with which that runoff reaches adjacent lakes, rivers, and wetlands. Increasing volume of water and its speed may increase the potential to move pollutants, increase the rate of erosion, and/or may minimize the effectiveness of various pollution prevention/mitigation measures.

Associated Terms and Phrases

Impervious surfaces: Impervious surfaces are mainly artificial structures—such as pavements (roads, sidewalks, driveways and parking lots) that are covered by impenetrable materials such as asphalt, concrete, brick, and stone--and rooftops. Soils compacted by urban development are also highly impervious (Wikipedia).

Target

Minnesota has not adopted limitations on the amount of impervious cover. Many BMPs are designed to mitigate the hydrologic and pollutant-carrying impacts associated with impervious surfaces. Stormwater rules and requirements seeks to minimize the impacts associated with impervious surfaces by identifying the types of BMPs that need to be implemented and/or settling specific water quality and quantity standards that need to be met.

Baseline

The methods of assigning and tracking changes in impervious surface coverage have changed. Instead of relying on standardized percent-impervious estimates for specific land-use activities, new techniques have been developed that use remote-sensing satellites to develop impervious cover estimates (see http://www.mrlc.gov/index.php). These methods have allowed the development of impervious estimates that are specific to particular landscape and that can be updated periodically over time using standardized techniques.

Geographical Coverage

Nation-wide developed area imperviousness data are available, the figures in this report were generated for the Twin Cities metro area, Rochester, and St. Cloud.

Data and Methodology

Methodology for Measure Calculation

The Multi-Resolution Land Characteristics Consortium (MRLC) is a cooperative partnership between federal agencies that have interests in land cover classification and change over time. MRLC produces several data products, including developed imperviousness data, which provide a consistently repeated source of data for this analysis. The MRLC website includes links to download the raw data and documentation detailing the development and validation of the data products (http://www.mrlc.gov).

Arnold, C. L., and C. J. Gibbons. (1996). Impervious surface coverage: the emergence of a key environmental indicator. *Journal of the American Planning Association*, 62(2): 243-258.

Xian, G., Homer, C., Dewitz, J., Fry, J., Hossain, N., and Wickham, J., 2011. The change of impervious surface area between 2001 and 2006 in the conterminous United States. *Photogrammetric Engineering and Remote Sensing*, Vol. 77(8): 758-762.

The Developed Surfaces Imperviousness model is derived from satellite imagery. The data is provided as a raster data product with a cell size of 30 meters. The raster cell values range from 0 to 100 and represent the percentage of land within the cell area that is covered by impervious surfaces. By averaging all of the grid cells that cover the 7-county metro area, a single value is derived to represent the percent imperviousness for the area of interest.

Data Source

The Multi-Resolution Land Characteristics Consortium coordinates the production of nation-wide land cover data between 10 cooperating federal agencies.

Data Collection Period

The developed impervious land cover data product has been produced every 5 years starting in 2001.

Data Collection Methodology and Frequency

The data collection and analysis methods are documented in detail in the following reports:

Vogelmann, J.E., T. Sohl, and S.M. Howard. 1998. Regional characterization of land cover using multiple sources of data. *Photogrammetric Engineering & Remote Sensing* 64: 45-57.
Homer, C., C. Huang, L. Yang, B. Wylie, and M. Coan, 2004. Development of a 2001 National Land Cover Database for the United States, Photogrammetric Engineering & Remote Sensing, 70(7):829-840

Xian, G., Homer, C., Dewitz, J., Fry, J., Hossain, N., and Wickham, J., 2011. The change of impervious surface area between 2001 and 2006 in the conterminous United States. *Photogrammetric Engineering and Remote Sensing*, Vol. 77(8): 758-762.

Other Measure Connections

Impervious surface coverage is one of three land-use changes being tracked to examine how external drivers may impact Minnesota's ability to achieve its Clean Water and Drinking Waters goals and is meant to be viewed in concert with measures in the population change and climate change categories. Tracking external drivers will also help Clean Water partners adapt their actions over time, enhancing water quality and drinking water outcomes.

Measure Points of Contact

Agency Information

Ben.Gosack@state.mn.us
Minnesota Department of Natural Resources, 500 Lafayette Road, St. Paul, MN 55155

Land-Use Changes – Wetland Cover

Measure Background

Visual Depiction

A graph showing estimated change in wetland cover statewide in Minnesota and/or by major landscape areas in comparison to the 2006 – 2008 baseline period was not included in the 2018 Clean Water Fund Performance Report because the amount of change observed was so small in comparison to the baseline. Small positive increases in wetland acreage were observed after the third, three-year, assessment interval (2015 – 2017) was completed and those results were report in the StarTribune (*Slight gain in Minnesota wetlands acreage, but quality in concerning*, October 12, 2017). Nevertheless, because the amount of increase was less than a tenth of one percent, a verbal description of the observed changed was judged to be sufficient.

Measure Description

Wetlands are important landscape features that provide many benefits. From a water-quality/drinking water perspective wetlands are important because they provide water storage, holding back runoff and reducing the intensity of flood peaks, reduce the concentration of various pollutants in runoff water, and contribute to groundwater recharge. Because of these benefits, Minnesota adopted a "no net loss" of wetland policy in 1991 (M.S. 103A201) and initiated a monitoring program in 2006 to track changes in wetland quality and quantity over time; this measure focuses on changes in quantity. If a major loss in wetland abundance is observed, increases in runoff rates and pollution loads are likely to occur that may impact Minnesota's ability to achieve identified Clean Water goals. Likewise, there may be a reduction in infiltration to replenish aquifers that are important drinking water resources.

Associated Terms and Phrases

Wetlands: For the purpose of this measure, wetlands include the following land cover classes: 1) deepwater (lakes, reservoirs, rivers, and streams), 2) forested wetlands (forested swamps), 3) shrub swamp (woody shrub or small tree marshlands), 4) emergent wetlands (marshes, wet meadows, and bogs), 5) aquatic bed (wetlands with floating and submerged plants), 6) unconsolidated bottom (open water wetlands, shore beaches and bars), and 7) cultivated wetland (wetlands in agricultural fields).

Target

Minnesota has adopted a no net loss policy goal. In addition, in some watersheds, wetland restoration may be an important strategy to increase hydrologic storage, improve water quality, and/or enhance other natural resource goals. However, the purpose of this measure is to track overall change in wetland acreage and no specific target is listed.

Baseline

Major changes in the abundance of wetlands have occurred in Minnesota since the state was first settled by people of European descent; it has been estimated that approximately half of the state's wetlands have been lost and in many parts of southern Minnesota well over 90 percent of the original wetlands have been drained. However, for the purpose of this stressor measure, the baseline period is 2006 – 2008; the three-year period when Minnesota's Wetland Status and Trends Monitoring Program (WSTMP) conducted its initial statewide assessment.

Geographical Coverage

This measure uses data from 4990 randomly selected permanent plots to estimate statewide trends as well as trends within the Minnesota's major ecological regions (e.g., Laurentian Mixed Forest, Eastern Broadleaf Forest, Prairie Parkland). Because of the high number and statewide coverage of the plots, the data could also be used to provide watershed and/or basin scale assessments as well.

Data and Methodology

Methodology for Measure Calculation

The data methods are described in detail in the three technical document referenced in the *Data Collection Methodology and Frequency* section (next page). In brief, changes in land cover are mapped for 4,990 randomly-selected, permanent plots located throughout Minnesota. All plots are one-square mile in area except for those that happen to fall on the state boundary, which are clipped to the boundary. Sampling occurs on a repeating three-year cycle: 250 plots are surveyed annually and the remaining 4,740 plots are divided equally into three sample panels with one panel surveyed each year of the sample cycle. Sample plot locations were selected using the generalized random tessellation stratified (GRTS) design (Stevens and Olsen 2004). The GRTS design was used to ensure adequate spatial distribution of sample plots. Land cover was mapped and classified for all plots for the initial, baseline sample cycle (T1, 2006 to 2008) using photo-interpretation and the data were stored in a GIS data layer. A GIS record, in the form of a polygon, was created for each photo-interpreted land cover feature. Special modifiers were added to the land cover attributes to indicate manmade (m) and artificially flooded features. Extensive field validation was used to measure the accuracy of the land cover classification (Kloiber 2010). The classification process correctly distinguishes between wetland and upland 94% of the time and correctly classifies the more detailed land cover types 89% of the time.

Land cover polygons from the baseline assessment (T1) were overlaid on aerial photography from the second sample cycle (T2, 2009 to 2011). Changes in wetland extent (gains, losses or change of type) were recorded by splitting land cover polygons as necessary to reflect changes and entering the updated land cover attribute in a second database field. Photo-interpreters also classified the cause of each change as either "direct" when there was direct visual evidence of the cause such as a new road or new drainage structure, or "indirect" when the cause of the change could not be ascertained from the imagery. The area and land cover change attributes for all polygons were imported into statistical software (JMP® version 10.0 - SAS Institute) for analysis. Features that did not change and non-target changes were excluded from further analysis. Non-target changes included changes between upland land uses and changes between upland and artificially flooded features. Features classified as artificially flooded typically serve an industrial or commercial purpose, have little natural wetland function, and usually do not meet the wetland definition. Examples include mine tailing discharge basins from active mining facilities and wastewater stabilization ponds. However, conversion of natural wetlands to a feature classified as artificially flooded was considered as a loss, and the reverse was regarded as a gain. Changes between wetland and deep-water habitats were treated as a change of wetland type rather than a wetland loss or gain. The acres of wetland gain, loss and change of type were tabulated for all sample plots. To extrapolate the results statewide, the area of the measured changes in each plot was first normalized by dividing by the plot size. We then calculated the mean of these normalized proportional changes and multiplied this by the area of the state. Since the program started in 2006, a key change in methods has involved the transition from aerial photographs to digital aerial images; the methods used to interpret and track changes in the images over time remains the same.

Data Source

The data for this measure are maintained by the agencies participating in the WSTMP effort; the wetland quantity database is maintained by the DNR.

Data Collection Period

The WSTMP began in 2006 and the first statewide assessment was completed in 2008; T1 (2006 – 2008) represents the baseline period. Data collection and analysis for the initial assessment interval (T2: 2009 – 2011) and data collection of the second assessment interval (T3: 2012 – 2014) has been completed. Data analysis for the T3 interval was still in progress when the 2016 Clean Water Fund Performance Report was being produced.

Data Collection Methodology and Frequency

The following three reports published by the DNR contain more thorough descriptions of data collection methodology:

1. Status and Trends of Wetlands in Minnesota: Wetland Quantity Trends from 2006 to 2011
2. Status and Trends of Wetlands in Minnesota: Wetland Quantity Baseline
3. Technical Procedures for the Minnesota Wetland Status and Trends Monitoring Program

Also see the following report:

Kloiber, S. M. and D. J. Norris, 2017, Monitoring Changes in Minnesota Wetland Area and Type from 2006 to 2014. *Wetland Science & Practice,* Vol. 34(3): 76-87.

Supporting Data Set

Extrapolating the baseline assessment of wetland coverage to a statewide value generate an estimate of 10.62 million acres, a big number. Because the change in wetland acreage between assessment intervals is likely to be small in comparison to the statewide total, the data at for subsequent time periods are reported as gains or losses from 10.62 million acres.

Time Period	Statewide Gain/Loss from Baseline (Acres)
T1- Baseline (2006 – 2008)	----
T2 (2009 – 2011)	2080
T3 (2012 – 2014)	6450
T4 (2015 – 2017)	Data analysis in progress

Caveats and Limitations

See discussion section (p. 14) in the first the three DNR reports cited above, *Status and Trends of Wetlands in Minnesota: Wetland Quantity Trends from 2006 to 2011*, (2013), that discuss challenges of determining long-term changes in the status of various types of wetlands from a series of aerial photos.

Other Measure Connections

Wetland coverage is one of three land-use changes being tracked to examine how external drivers may impact Minnesota's ability to achieve its Clean Water and Drinking Waters goals and is meant to be viewed in concert with measures in the population change and climate change categories. Tracking external drivers will also help Clean Water partners adapt their actions over time, enhancing water quality and drinking water outcomes.

Measure Points of Contact

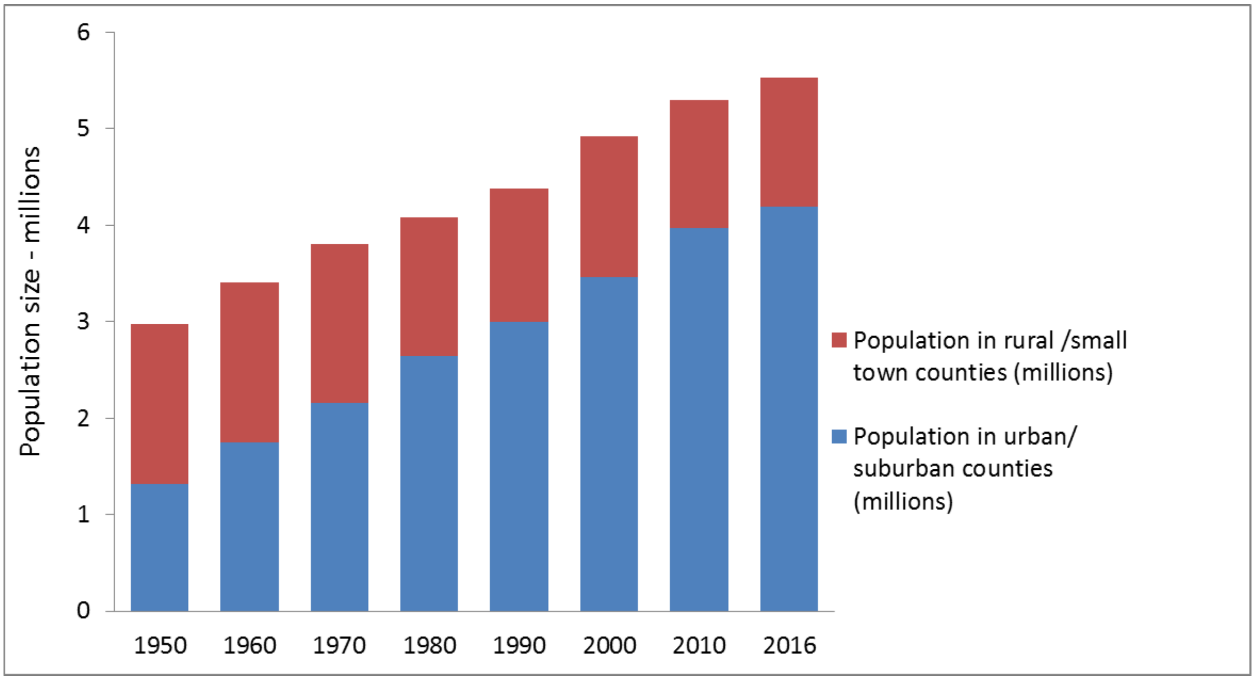
Agency Information

Steve Kloiber
Wetland Monitoring Coordinator,
Division of Ecological and Water Resources – Box 25,
Minnesota Department of Natural Resource,
500 Lafayette Road,
Saint Paul, MN 55155
steve.kloiber@state.mn.us or 651-259-5164

Demographic Changes – Population Size & Proportion Urban/Suburban

Measure Background

Visual Depiction



Measure Description

People are the cause of most of the water quality problems in Minnesota. As a result, as the population size of the state increases, the challenge associated with obtaining and maintaining good water quality in the state's lakes, rivers, and wetlands is likely to rise. In addition to population size, where people live, how they use the state's land and water resources, (see Land-use External Drivers above), and their expectations about resource protection/resource use will influence the success of Clean Water investments. Many aspects of how Minnesota's population is changing over time are tracked by the US Census Bureau. This measure reports on the following two demographic attributes: 1) population size and 2) urban/suburban vs. rural residents. The attributes are paired (see graph above) to reflect to how the state's population is growing and becoming more urban/suburban.

Associated Terms and Phrases

Demographics: Relating to the dynamic balance of a population especially with regard to density and capacity for expansion or decline of time

Urban vs. Rural: For many years the Census Bureau's official urban vs. rural definition was dichotomous: places of 2,500 or more residents were considered urban, and those with fewer were considered rural. These historical data are looking at the unit of the incorporated place, and then basically counting up heads. However, the Census' more modern definition of Urban Areas/Urban Clusters/Rural (UAs/UCs/Rural) applies both a resident-based definition (UAs=50,000 people or more, UCs=2,500-49,999, and Rural=less than 2,499) in addition to examining the density of development at the tract or block level, so it is a much refined method. Thus, for example, a defined "urban cluster" that is home to 30,000 residents in the Census count may only count 25,000 of them as living in the UC if some live in low-density areas (that are still part of the incorporated place). Here's a map showing Urbanized Areas and Urban Clusters.

Target

There is no target associated with this measure

Baseline

Information on the size of Minnesota's population was obtained from U.S. Census Bureau, Decennial Census and U.S. Census, American Community Survey data as compiled by Minnesota Compass (www.mncompass.org). Minnesota Compass has chosen to use 1950 of the baseline for the demographic data report on their site and that convention was followed. Using 1950 as a baseline with census data allows multiple data points prior to the present to be shown which helps identify trends that are occurring over time and identify whether population-related stressors may be increasing or decreasing in importance.

Information on the proportion of Minnesotan's living in urban counties was provided the by the State Demographer. The Demographer's office provided a table showing the share of Minnesota's state population that lived in counties defined as part of a metropolitan statistical area (MSA) each decade from 1950 to 2010. This somewhat blunt unit measure for defining urban or rural is the county, and it is important to note that the counties comprising each MSA changed over time as population centers grow. By this definition, in 2010, 75% of MN residents lived in urban areas, while the remaining 25% lived in rural areas. While not the most accurate measure for defining the proportion of Minnesotan's that are urban vs. rural, it is helpful because of the longer period over which data are available for trend determination.

A similar urban vs. rural split was used in a recent report from the U.S. Dept of Agriculture, "Rural America at a Glance 2012" <http://www.ers.usda.gov/media/965908/eb-21_single_pages.pdf.

Geographical Coverage

Statewide

Data and Methodology

Methodology for Measure Calculation

Data Source

U.S Census Bureau, Decennial Census http://factfinder2.census.gov/main.html and U.S. Census Bureau, Population Estimates http://www.census.gov/popest/ as compiled and report at www.mncompass.org/demographics/ or as compiled by the State Demographer's Office.

Data Collection Period

1950 to the present, in ten year increments, a pattern that reflects the frequency of the U.S. Census and the format of demographic data present by Minnesota Compass. The most recent data available from the State Demographer's Office is also presented.

Data Collection Methodology and Frequency

See www.mncompass.org/demographics/ and other resources linked to that site; also see U.S. Dept of Agriculture, "Rural America at a Glance 2012" http://www.ers.usda.gov/media/965908/eb-21_single_pages.pdf.

Supporting Data Set

Year	Population Size (millions)	Population in Urban/Suburban Counties (millions)
1950	2.98	1.32
1960	3.41	1.75
1970	3.80	2.16
1980	4.08	2.64
1990	4.38	3.00
2000	4.92	3.46
2010	5.30	3.99
2016	5.53	4.20

Caveats and Limitations

See www.mncompass.org/demographics/ for a discussion of the caveats and limitations associated with the data represented in this measure.

Other Measure Connections

Population size and proportion urban/suburban are two demographic changes being tracked to examine how external drivers may impact Minnesota's ability to achieve its Clean Water and Drinking Waters goals and is meant to be viewed in concert with measures in the land-use and climate change categories. Tracking external drivers will also help Clean Water partners adapt their actions over time, enhancing water quality and drinking water outcomes.

Measure Points of Contact

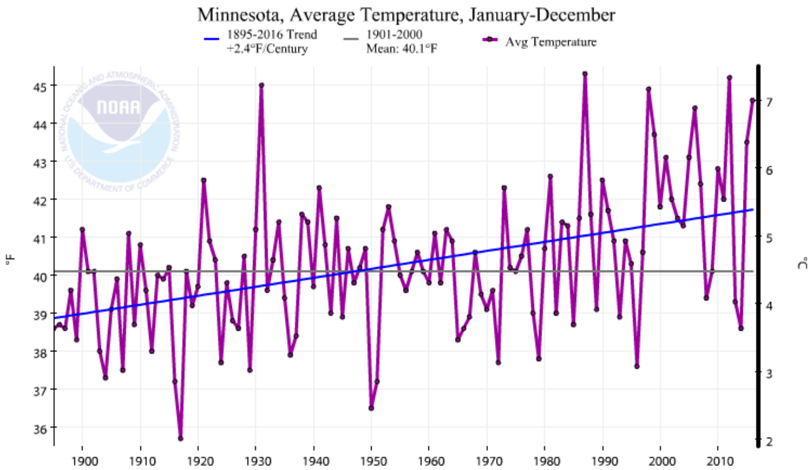
Craig Helmstetter
craig.helmstetter@wilder.org
Wilder Research | 451 Lexington Parkway North | St. Paul, MN 55104

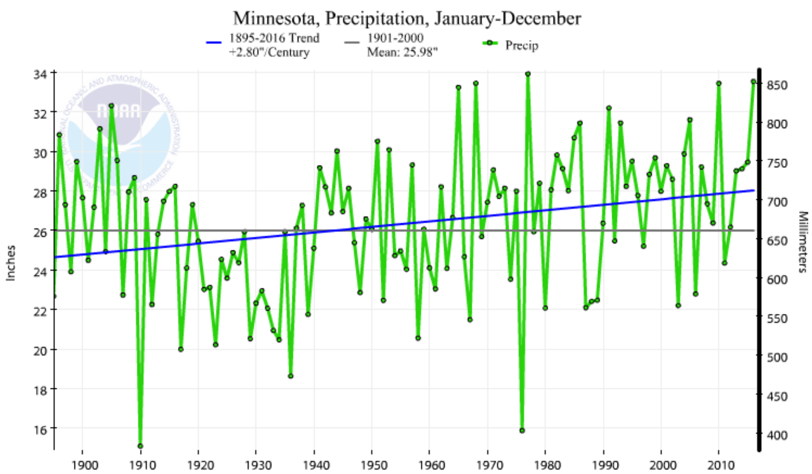
Susan Brower
susan.brower@state.mn.us
MN State Demographic Center |651-201-2474|

Climate Changes – Average Annual Temperature and Precipitation in Minnesota

Measure Background

Visual Depiction





Measure Description

Data collected from many sources is suggesting that the amount of variability associated with climate patterns in Minnesota as well as the movement of water through various parts of hydrologic cycle is increasing. Because these changes may impact Minnesota's ability to achieve its clean water goals, understanding how climate and hydrologic variability is increasing, how those changes will alter how water and pollutants move between terrestrial and aquatic systems, and identifying adjustments that may be necessary to identified clean water protection and restoration strategies will be critical. This measure highlights one measure related to temperature, average annual temperature, and one measure related to precipitation, average annual precipitation, from among the multiple options available.

Associated Terms and Phrases

Climate patterns – A climate pattern is any recurring characteristic of the climate. Climate patterns can last tens of thousands of years, like the glacial and interglacial periods within ice ages, or repeat each year, like monsoons. A climate pattern may come in the form of a regular cycle, like the diurnal cycle or the seasonal cycle; a quasi-periodic event, like El Niño; or a highly irregular event, such as a volcanic winter. The regular cycles are generally well understood and may be removed by normalization. (Wikipedia)

Hydrologic cycle – The hydrologic cycle describes the continuous movement of water on, above and below the surface of the Earth. Although the balance of water on Earth remains fairly constant over time, individual water molecules can come and go, in and out of the atmosphere. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. In so doing, the water goes through different phases: liquid, solid (ice), and gas (vapor). Adapted from Wikipedia.

Target
There is no target associated with this measure

Baseline
There is no baseline associated with the long-term changes in average annual temperature and precipitation in MN.

Geographical Coverage
Statewide

Data and Methodology

Methodology for Measure Calculation

Data Source
The Minnesota Department of Natural Resources (MNDNR) State Climatology Office (http://www.dnr.state.mn.us/waters/groundwater_section/climatology/index.html) exists to gather, archive, manage, and disseminate historical climate data in order to address questions involving the impact of climate on Minnesota and its citizens.
In order to provide its services, the MNDNR State Climatology Office (SCO) requires an extensive historical climate data set. The SCO utilizes data managed locally, as well as data administered by national climate monitoring efforts.

National Weather Service Cooperative Observer Network
The National Weather Service (formerly the U.S. Weather Bureau) has maintained a large-scale, volunteer-based climate monitoring network in Minnesota since 1890. National Weather Service volunteers make daily measurements of maximum and minimum temperature, rainfall, snowfall, and snow depth. There are approximately 150 National Weather Service volunteers presently active in Minnesota. The data set is managed by the National Climate Data Center and their partner Regional Climate Centers. Historical time-trends of statewide and regional data can be viewed at

http://www.ncdc.noaa.gov/cag. Access to daily data is accomplished via http://xmacis.rcc-acis.org.

MNGage

The MNGage data base features data collected by Minnesota's unique high spatial density precipitation monitoring program. The program was formed in the early 1970s to fill in geographic gaps between National Weather Service reporting locations. The program is made up of a "network of networks", utilizing the efforts of water-oriented state and local agencies to assemble daily precipitation data collected by approximately 1500 volunteer precipitation observers. Cooperating agencies include: Soil and Water Conservation Districts, Watershed Districts, DNR Forestry, and others. The cooperating agencies recruit volunteers, distribute monitoring equipment, distribute monitoring forms and instruction, and assure that the data are delivered to the SCO. In turn, the SCO provides cooperators with rain gauges, guidance regarding network management, value-added data analysis, and a variety of on-line tools which allow the agencies to enter, manage, and retrieve precipitation data. The precipitation data base managed by the SCO (see: http://climate.umn.edu/mngage).

CoCoRaHS

CoCoRaHS is an acronym for the Community Collaborative Rain, Hail and Snow Network. CoCoRaHS is a national, non-profit, community-based network of volunteers working together to measure and map precipitation. The program utilizes low-cost measurement tools, stresses training and education, and utilizes an interactive Web-site for data entry and retrieval. Volunteers report daily measurements of rainfall, snowfall, snow depth and hail. Over 2000 Minnesotans have participated in CoCoRaHS since its Minnesota debut in late 2009. The data set is managed by the CoCoRaHS organization and can be accessed at http://www.cocorahs.org.

Data Collection Period

The measures related to long-term changes in Minnesota's average annual temperature and precipitation cover the period 1895 to the present.

Data Collection Methodology and Frequency

Details about the specific data collection methodologies and frequencies involved to tracking long-term average annual temperature and precipitation patterns for Minnesota are available by contacting the MN Department of Natural Resources State Climatology Office (http://www.dnr.state.mn.us/waters/groundwater_section/climatology/index.html).

Other Measure Connections

Average annual temperature and average annual precipitation are two climate changes being tracked to examine how external drivers may impact Minnesota's ability to achieve its Clean Water and Drinking Waters goals and is meant to be viewed in concert with measures in the land-use and demographic change categories. Tracking external drivers will also help Clean Water partners adapt their actions over time, enhancing water quality and drinking water outcomes.

Measure Points of Contact

Agency Information

MN Department of Natural Resources State Climatology Office
(http://www.dnr.state.mn.us/waters/groundwater_section/climatology/index.html).

Social Measures

SOCIAL MEASURES MONITORING SYSTEM

Overview and Metadata Sheets

by

Mae A. Davenport, Ph.D.,
Department of Forest Resources
College of Food, Agricultural and Natural Resource Sciences
University of Minnesota
115 Green Hall
1530 Cleveland Avenue North
St. Paul, MN 55108-6112
www.forestry.umn.edu

Prepared on behalf of the Minnesota Clean Water Fund (CWF) Interagency Social Measures Subteam including representatives from Minnesota Department of Agriculture (MDA), Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (DNR), Minnesota Department of Health (MDH), Minnesota Board of Water and Soil Resources (BWSR), University of MN Extension-Leadership and Civic Engagement, and University of Minnesota-Department of Forest Resources

on

August 30, 2013.

State agency contact information updated 2018.

This report is a guidance document to inform planning, tracking and reporting on the social outcomes of Clean Water Funds from Minnesota's Clean Water, Land and Legacy Amendment. The Social Measures Monitoring System (SMMS), which consists of an overview and five metadata sheets, will be adapted and refined for agency use under the direction of the Interagency Social Measures Subteam.

The SMMS is in a piloting phase and being applied to projects within different state agencies to inform and develop program specific procedures. For more information on the SMMS contact Dr. Mae Davenport or members of the Interagency Social Measures Subteam. The SMMS development project was funded by MDA, MPCA, DNR, MDH and BWSR. Results from SMMS piloting will be presented in the Clean Water Fund Performance Report. The Report, published every two years, tracks the connections between Clean Water Funds invested, water resource management actions taken and clean water outcomes achieved.

Table of Contents

Social Measures Monitoring System Overview[1]

Social Measures Background

Social measures monitoring tracks community capacity to engage in water resource management

The social measures monitoring system is a systematic and science-based framework for gathering data on community capacity to engage in water resource protection and restoration. The monitoring system is designed for two primary purposes: (1) to assess and monitor over time community capacity to engage in water resource protection and restoration and (2) to provide a protocol for determining the effects of water resource education, outreach and civic engagement activities and programs on community capacity. At an administrative level, the system will track the extent to which Clean Water Fund investments are increasing community capacity to get water resource projects done. At the project level, the monitoring system also will enable water resource project managers and community leaders to enhance or support a community's ability to engage in water resource protection and restoration in the future.

To date there has been no systematic effort to compile or synthesize social data for water resource management. The social measures monitoring system begins to fill this need. Given that the system is new, it is anticipated that social measures monitoring will continue to evolve as it is implemented and refined at the project level.

The social measures monitoring system is anchored by five social measures (Figure 1) that take into account the full spectrum of community capacities including individual decision-making (SM1), relationships between individuals (SM2), organizations that influence the community and water resources (SM3), and programs designed to support community and water resource goals (SM4). The system also includes a measure for tracking perceived fairness and legitimacy of water resource management (SM5). The monitoring system provides a holistic and flexible set of social measures and indicators that can be tailored to a project's audience (e.g., lakeshore owners, agricultural producers, municipal officials, civic engagement program participants) and scale (e.g., neighborhood, stream segment, county, watershed).

The monitoring system is detailed in this Social Measures Monitoring System Overview and five Social Measures Metadata Sheets (SM1-5, Appendix A). These materials are intended to provide a standard framework of measures and indicators related to community capacity, as well as a common language for social measures monitoring. The Social Measures Monitoring System Overview offers insight on data collection tools and strategies for implementation. However, the document does not provide step-by-step instruction on monitoring procedures. Additional supporting resources on community capacity data collection tools and methods including published reports of past monitoring efforts and social science assessment tools are listed in the appendices.

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[1] Suggested Citation: Davenport, M.A. (2013). Social measures monitoring system overview. Report prepared for the Clean Water Fund Tracking Framework. St. Paul, MN: Department of Forest Resources, University of Minnesota. 31 pp.

SM1. Change over time in individual capacity to be engaged in water resource protection and restoration
SM2. Change over time in relational capacity to be engaged in water resource protection and restoration
SM3. Change over time in organizational capacity to be engaged in water resource protection and restoration
SM4. Change over time in programmatic capacity to be engaged in water resource protection and restoration
SM5. Water resource management is perceived as fair and legitimate

Figure 1. Social Measures 1-5

A multilevel community capacity model is the foundation for social measures monitoring

Sociologists and community organizers have long studied the concept of community capacity and what makes some communities better than others at working together and responding to problems. Chaskin et al. (2001, p. 7) describe community capacity as the "interaction of human capital, organizational resources, and social capital existing within a given community that can be leveraged to solve collective problems and improve or maintain the well-being of that community." According to these authors, community capacity "may operate through informal social processes and/or organized efforts by individuals, organizations, and social networks that exist among them and between them and the larger systems of which the community is a part." Scientists and policy experts in the area of water resource management recently have argued that a greater understanding of community capacity to engage in sustainable watershed management and to adapt to changing social-ecological conditions is needed for more effective water resource protection (Braden et al. 2009, Tarlock 2003, Bradshaw 2003, Sabatier et al. 2005, Morton 2008). In turn, Davenport and Seekamp (2013) developed a Multilevel Community Capacity Model (Figures 2 and 3) to guide water resource managers in assessing and monitoring community capacity for watershed projects. The model was developed through an extensive review of community capacity and community resilience literature. The social measures monitoring system is grounded in this model and its indicators are supported by decades of social science theory, research and field practice.

Prior to developing the social measures monitoring system, several existing social measures frameworks and processes were considered (e.g., Social Indicator Planning and Evaluation System (Genskow & Prokopy 2011), Knowledge, Attitudes and Practices assessment (see Eckman & Consoer 2012), and the community capitals framework (Flora 2004)). However, given agency interest in the community capacity framework (Davenport & Seekamp 2013) and broader needs associated with tracking *community* outcomes of water projects in Minnesota, the social measures monitoring project was initiated.

It has become increasingly evident to science and policy experts that healthy ecosystems and healthy social systems are interdependent and mutually supporting. Social measures are aimed at enhancing community capacity to engage in water resource protection and restoration. Social measures help us understand and enhance the relationship between ecosystems and social systems by answering three overarching questions: (1) What drives communities to engage in sustainable water resource management? (2) What constrains communities from engaging in sustainable water resource management? (3) How can resource professionals, policy-makers, and citizens build community capacity to protect and restore Minnesota's water resources?

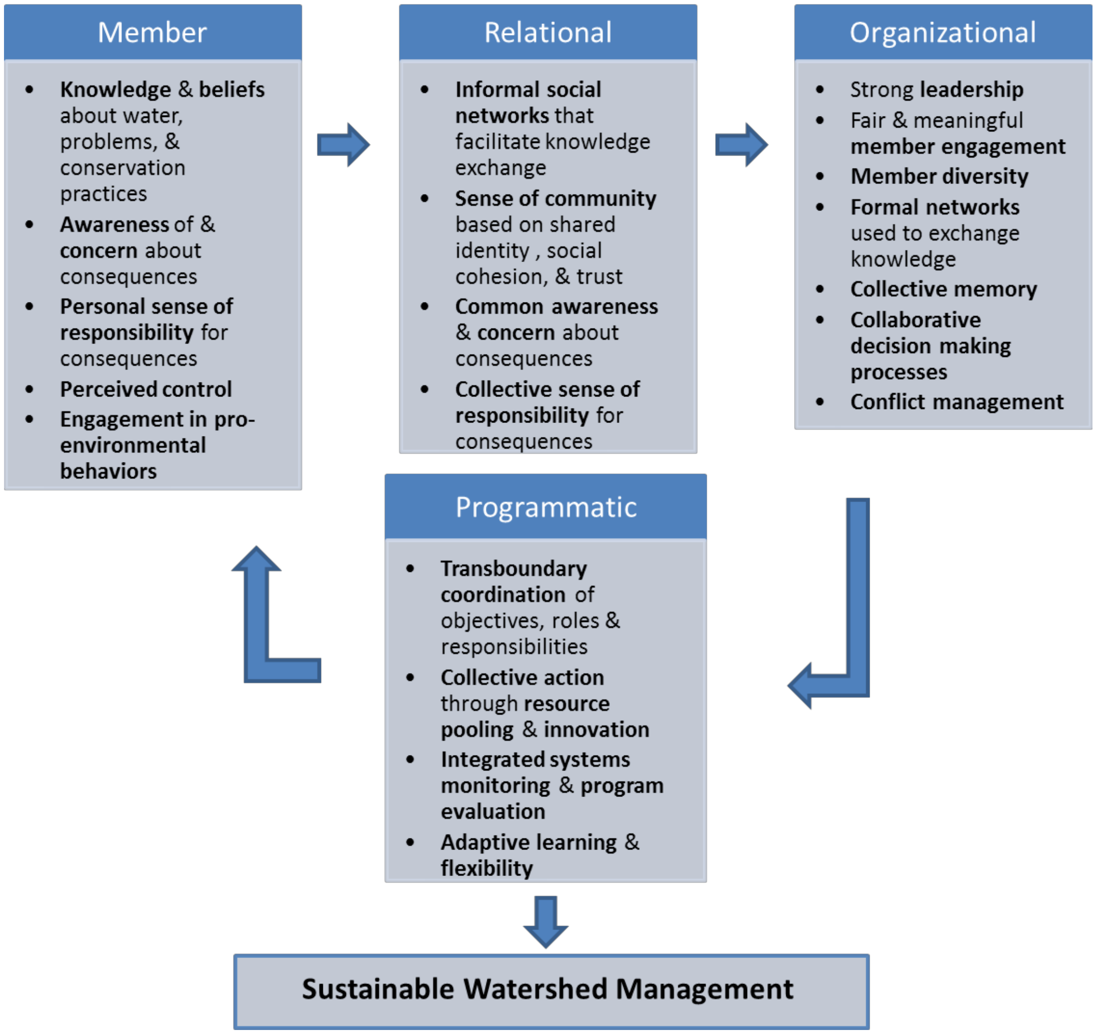


Figure 2. Multilevel Community Capacity Model (Davenport & Seekamp 2013)

Davenport and Seekamp (2013) highlight important differences between community capital and community capacity (Figure 3):

> "While *community capital* encompasses a variety of foundational resources or assets (e.g., physical, financial, technological) upon which a community can draw in times of need, *community capacity* is the interaction, mobilization and activation of these assets toward social or institutional change. Stated differently, a community may possess a broad range of capitals needed to cope with problems…but lack the capacity to establish common goals, make decisions based on mutual learning, and act collectively."

Additionally, recent research points to the important role of justice and in particular, perceived fairness in decision making processes, outcomes and stakeholder interactions in natural resource and water resource management (Figure 3, Larson & Lach 2010, Lauber & Knuth 1998, Smith & McDonough 2001, Wutich et al. 2013). Perceptions of procedural fairness have been correlated with increased satisfaction with the process itself, perceived fairness in resulting decisions, and satisfaction with the managing organization. Perceived legitimacy, including organization, program and decision legitimacy (Lockwood et al. 2010), also plays a critical role in water resource management and if lacking, can be a barrier to civic engagement (Jordan et al. 2011).

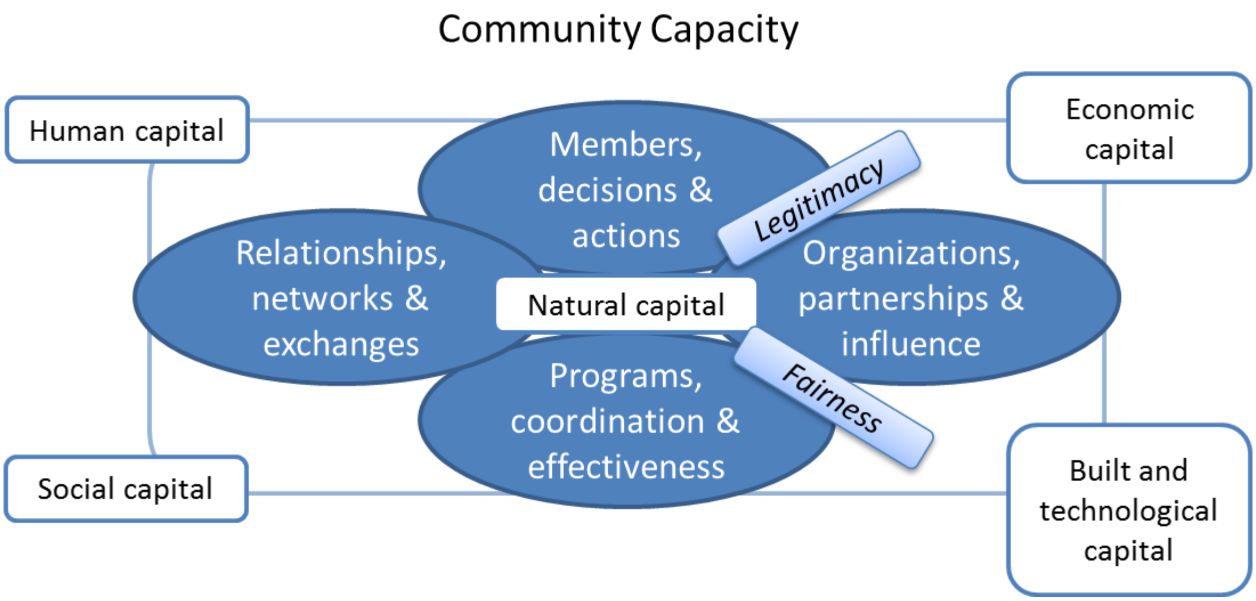


Figure 3. Relationship between community capacity, legitimacy and fairness, and community capitals

Monitoring social measures enhances water resource decision-making

Despite advances in biophysical science, technology and engineering, questions persist around the human and social dimensions of water resource protection and restoration including what drives conservation practices and how can communities become better engaged. Water resource management requires not only technical solutions, but also the commitment and action of diverse stakeholders, from residents and landowners to business owners and local government officials. Thus, water resource professionals are increasingly seeking guidance from social scientists and outreach and communication specialists to better understand and influence people and their behaviors.

In the last decade an increasing amount of social data has been gathered to inform water resource management in Minnesota. However, there has been no systematic effort to compile or synthesize this information to date. Furthermore, many data collection efforts lack science-based or standardized measures to enable meaningful comparison or aggregation. The majority of past assessment projects have focused on the individual behaviors, and in particular human beliefs and behaviors. Much like using a watershed approach to monitoring the impacts of projects on water quality, monitoring the impacts of projects on people and their actions requires a *community* approach. Efforts to track awareness or behavior one individual at a time may prove too costly and time consuming to be implemented at a broad scale or to be sustained over time. Moreover, individual behaviors do not occur in isolation; rather they are influenced by the social structures and processes in which an individual lives, works and recreates. Perhaps most importantly, however, is that water resource protection and restoration at a watershed scale requires community-scale action across land uses, ownership boundaries and governmental jurisdictions. Without the coordinated efforts of residents, property/business owners, organizations, local government units and entire communities, water resource problems persist. Thus, a community scale becomes the most efficient and effective means for tracking social measures.

Using social measures alongside biophysical measures in water resource management provides critical understanding of who stakeholders are, what water resources mean to them, how they interact with water resources, and what motivates them to engage in conservation. It also helps project managers determine the overall readiness of a community, including its organizations and programs, to engage in water resource protection and restoration and guides managers in designing programs that not only motivates community members but also build long-term capacity for future engagement.

The social measures are grounded in five key principles:

- **Science-based**: Biological, chemical and physical models are used to provide the structure and framework for assessing water quality, quantity and timing conditions and evaluating progress toward targets or thresholds. Similarly, effective assessment of human and social conditions relies on a social science framework. The social measures, core indicators and project-specific indicators are grounded in sociology, psychology and applied social science disciplines.
- **Outcomes-focused**: While tracking *outputs* (i.e., products like number of newsletters distributed and services such as hours of technical assistance provided) is informative, tracking *outcomes* or the real beneficial and non-beneficial consequences of water resource and civic engagement programming to humans and communities is critical. Outcomes (e.g., enhanced individual sense of personal responsibility for water resource consequences, strengthened social networks for knowledge exchange, increased member diversity among organizations, and better coordinated programs) are the best indication of progress towards building community capacity and toward desired water resource conditions, because outcomes represent the true targets.
- **Systematic and flexible**: Monitoring systems must be consistent and reliable, yet remain flexible enough to be applied under varying conditions and contexts. The social measures (SM1-SM5) provide a systematic framework for tracking indicators across multiple state agencies. SM1-SM5, their core indicators, and project-specific indicators are derived from the same conceptual foundation and thus, will ensure a common monitoring language between projects. At each level, agencies and project managers have increasing ability to tailor the measures for particular projects and programs. Still, each project-specific indicator is linked to a core indicator and a social measure which allows for scaling-up and aggregation of effectiveness tracking. Furthermore, though performance standards may vary project to project, the framework enables consistency and continuity in reporting. Depending on agency and project resources, managers may track single or multiple project-specific indicators for one or all of the core indicators in each measure. The more intensive the assessment and evaluation plan, the more detailed and precise the monitoring results will be.
- **Practical**: The social measures community capacity framework is designed to be applied with a range of available financial and human resources. The project-specific indicators and monitoring tools allow managers and staff to determine their own monitoring intensity from very basic to more advanced monitoring. Regardless of the number of core indicators

monitored or the intensity of the monitoring program, managers can rest assured that the system is science-based and reliable.

- **Aspirational**: The monitoring system is aspiration in that it provides a mechanism and vision for state-wide and comprehensive tracking of community capacity to engage in water resource protection and restoration. To that end, it offers every project, regardless of resources or timeline, a practical entry point for social measures tracking. The framework promotes co-learning, resource pooling and creativity within the system as it is more widely applied. Yet, because measures and indicators are consistent, managers and staff will be building on the existing body of knowledge within and across watersheds and regions. The system acknowledges ongoing efforts to balance increasing social measures monitoring needs with resource availability.

Linking Civic Engagement to the Social Measures Monitoring System

The inclusion of social measures in the Clean Water Fund Effectiveness Tracking Framework acknowledges that clean water is achieved by the actions and commitment of diverse groups of individuals working in concert to identify and solve water quality problems. Improvements in water quality are realized when Minnesotan's fully engage in, support and lead clean water efforts. The key concept is citizens must get involved in water resource management for significant improvements to occur. Engaging and involving citizens in water resource management requires education, outreach and civic engagement. These activities build community capacity and provide the necessary tools and resources for citizens to protect and restore waters now and in the future.

The social measures monitoring system (SMMS) provides insights that allow watershed managers and others to adaptively manage the complexities involved in developing community capacity for addressing water resource issues. Education, outreach and civic engagement are related to the SMMS in three important ways:

- Civic engagement methods can be used to build relationships and gather information for assessments. This information can be used to monitor and assess changes in community capacity.
- The findings from the SMMS can help inform the design of education, outreach and civic engagement.
- The findings from the SMMS can help evaluate the outcome of education, outreach and civic engagement. Findings provide valuable information about how to adapt education, outreach and civic engagement strategies for success.

The SMMS and assessments conducted using this approach are not civic engagement in and of themselves. Engagement is the application of wide range of principles, standards and practices that help guide work aimed at involving people in identifying and solving water quality problems. Well-designed civic engagement recognizes the importance of processes and structures to achieve broad participation and collaborative problem-solving.

Social Measures Monitoring System Description

The Multilevel Community Capacity Model (MCCM) for sustainable watershed management (Davenport & Seekamp 2013, Figure 2) provides a framework for guiding monitoring, evaluating and community capacity-building efforts in water resource protection and restoration. The model is based on an extensive literature review in fields of psychology, sociology, community development and public health (Chaskin et al. 2001, Foster-Fishman et al. 2001, Goodman et al. 1998, Manning 2009); empirical research conducted in Minnesota and the Midwest; and ongoing dialogue with water resource professionals and policy-makers. The model establishes community assets, needs, capacities and incapacities that shape community engagement in water resource protection and restoration.

The MCCM identifies four levels of community capacity:

- **Member capacity** refers to community members' knowledge and beliefs, awareness and concern, sense of personal responsibility and perceived control associated with water resource problems and their consequences. Altogether these capacities contribute to engagement in pro-environmental behaviors.
- **Relational capacity** encompasses interpersonal relationships and social networks within communities that promote knowledge exchange and sense of community. Common awareness and concern promotes a collective sense of responsibility for water resource consequences.
- **Organizational capacity** includes strong leadership, meaningful member engagement, formal networks, and collective memory. High capacity non-government and government organizations engage in collaborative decision making processes and are effective at conflict management.
- **Programmatic capacity** relates to transboundary coordination, resource pooling and innovation for collective action, and integrated biophysical and social systems monitoring and evaluation. Water resource and civic engagement programs should be flexible and adaptive.

Davenport and Seekamp (2013) describe the four levels of capacity as mutually supporting. For instance, a high level of programmatic capacity (e.g., coordinated education programs about the consequences of urban and rural land uses on water quality) will enhance member capacity (e.g., members will have a more holistic understanding of land use impacts). Higher member capacity (e.g., members who understand land use impacts) will enhance relational capacity (e.g., more informed informal social networks). The authors also note that tracking community capacity over time across communities is important because community capacity is dynamic and multi-dimensional.

The MCCM provides a framework to assess the outcomes of water projects on community capacity to engage in water resource protection and restoration. It establishes multiple indicators that can be used to monitor progress in community capacity-building towards both short-and long-term goals. The model enables project managers to more holistically and reliably plan and track the effects of projects, specifically the impact they have on individuals and communities. The MCCM is the foundation upon which the social measures monitoring system was developed.

The social measures monitoring system is organized as a nested hierarchy with three basic levels: measures, core indicators and project-specific indicators (Figure 4). At the highest level are the social measures (SM) 1-5 (Figure 1). SM 1-4 correlate with the four levels of community capacity (Figure 2). For example, at the individual capacity level (SM1) managers track individual stakeholder awareness of problems, concern about consequences and ability to engage in pro-environmental behaviors. In SM1 managers ask “How do individual stakeholders affect water resources?” and “How does my project affect individual stakeholders?” At the relational level (SM2) managers track how individuals share information and influence one another. In SM2 managers consider “How do relationships and exchanges between stakeholders affect water resources?” and “How does my project affect relationships and exchanges between stakeholders?” At the organizational level (SM3) managers track community organizations and how they function. In SM3 managers ask “How do community organizations affect water resources?” and “How does my project affect community organizations? At the programmatic level (SM4) managers track community programs and their influence in the community. In SM4 managers ask “How do community programs affect water resources?” and “How does my project affect community programs?” A fifth measure (SM5), not explicitly referenced in the MCCM, enables managers to track fairness and legitimacy of water programs within a community. The concepts of fairness and legitimacy have been identified in recent research as significant to community capacity to engage in water resource protection and restoration (Pradhananga & Davenport 2013). In SM5 managers ask “Is water resource management perceived as fair and legitimate in the community?” and “How does my project affect perceptions of fairness and legitimacy?”

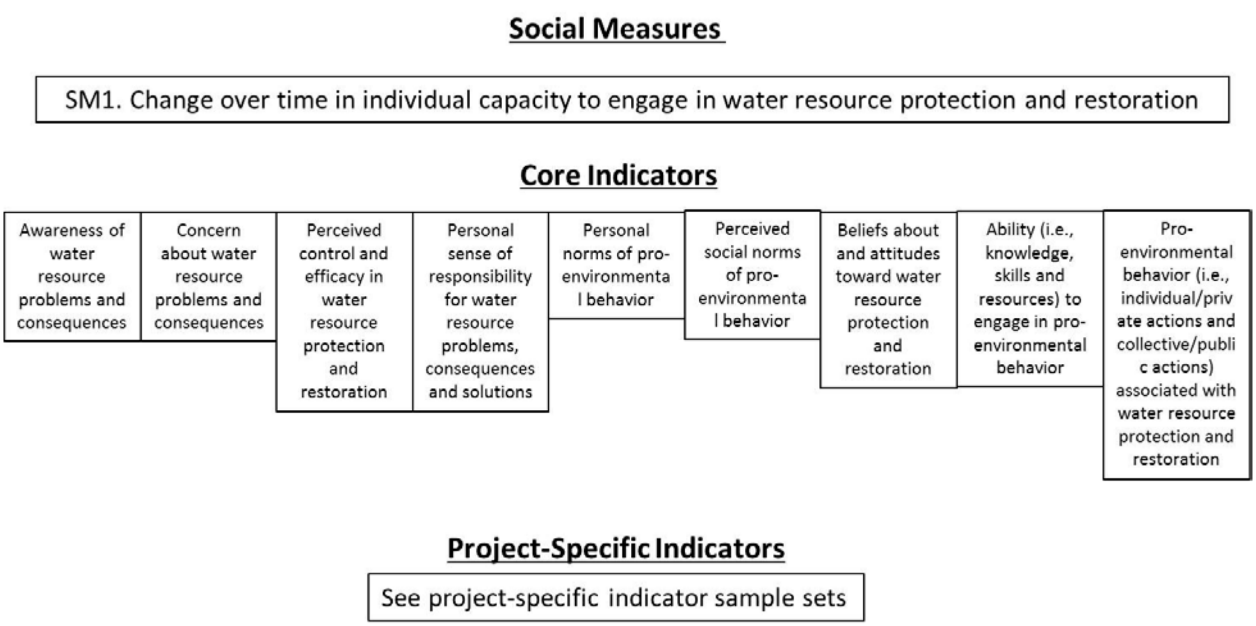


Figure 4. Organizational model for social measures monitoring system
Note: This model is further supported by the Data and Methodology section and Appendices A-C.

Each social measure consists of multiple core indicators and each core indicator has one or more project-specific indicators. For example, SM1 is *change over time in individual capacity to be engaged in water resource protection and restoration*. SM1 consists of nine core indicators including *awareness of water resource problems and consequences* (SM1.1), *ability to engage in pro-environmental behavior* (SM1.8), and *pro-environmental behaviors associated with water resource protection and restoration* (SM1.9).

Project managers are encouraged to monitor as many core indicators as possible. SM1.9 has multiple project-specific indicators including *stakeholders have adopted the appropriate conservation practices*, *stakeholders are talking to other community members about conservation practice*, and *stakeholders are participating in volunteer events*. Project-specific indicators show progress made for each core indicator.

Visual Depiction

Visual depictions of social measures monitoring results at the core and project-specific indicator level will vary depending on the monitoring tool and the type of data (i.e., quantitative, qualitative, spatial) gathered. Quantitative data output may be displayed as descriptive statistics, frequency tables, and graphics (e.g., bar/pie charts for comparisons/trends, spatial analysis maps). Qualitative data output may consist of direct quotes, theme tables, and graphics (e.g., concept maps, decision frameworks, word clouds).

Synthesis and summary data at the social measures level may be displayed in a watershed report card or a summary matrix (Figure 5). More detail about synthesis and project summaries will be developed during social measures monitoring system piloting.

Social Measures Summary Matrix *Name of community:*

	Attributes					
Source:	SM1 Individual Capacity	SM2 Relational Capacity	SM3 Organizational Capacity	SM4 Programmatic Capacity	SM5 Legitimacy &Fairness	Data Notes
Participatory Scoping						
Secondary Data						
Interviews						
Surveys						
Focus Groups						
Overall						
Measure Notes						

*Copy and paste the correct arrow into each capacity box.

The top four rows include assessments on each of the 5 measures
The fifth row is an overall summary for each measure that synthesizes findings from the assessments conducted

Figure 5. Social measures summary matrix (adapted from Gustanski et al. 2009)

Associated Terms and Phrases

Civic engagement definitions relevant to social measures monitoring include

- "Making public decisions and taking collective actions through processes that involve discussion, reasoning, and citizen participation *rather than* through the exercise of authority, expertise, status, political weight, or other such forms of power" (Fagatto & Fung 2009).
- **"**Making resourceFULL decisions and taking collective action on public issues through processes of public discussion, reflection and collaboration. Outcomes of authentic civic engagement are resourceFULL decisions and collective action. This requires intentionality and a holistic, rather than piecemeal, approach to civic engagement process design and management. A resourceFULL decision is one based on diverse sources of information and supported with buy-in, resources (including human), and competence. Obtaining diverse sources of information requires intentionality about who is engaged to provide a wide range of perspectives, knowledge, wisdom and experiences relative to the public issue". (Radke et al. 2012)

Community is a difficult concept to define, because a community is the intersection of people, places, interests, and social interactions. Kenneth Wilkinson (1991, p. 2), renowned rural sociologist who studied human-environment interactions, described a community as the combination of three elements: the "local society" (or the community of interest), the "locality" (or the community of place) and the "community field" (or the community of social interaction). Under this definition a community might be a municipality or township, but it can also be a grouping of lakeshore landowners or farmers within a watershed. A community of interest could be defined as formal decision-makers who have authority in land and water use decisions. It is important to think about community as being more than residents in an area defined by political boundaries or even watershed boundaries. All three elements of community should be considered when designing or convening a civic engagement process or when planning a community capacity assessment.

Community capacity, according to Chaskin et al. (2001, p. 7), "is the interaction of human capital, organizational resources, and social capital existing within a given community that can be leveraged to solve collective problems and improve or maintain the well-being of that community."

Monitoring tools: Social measures monitoring collection tools include participatory scoping, secondary data analysis, interviews, surveys, focus groups, and observation.

Pro-environmental behaviors are broadly defined and encompass private-sphere actions like land and water use conservation (e.g., rain garden installation and the maintenance of streamside buffers), as well as public-sphere actions like conservation citizenship (e.g., attending a watershed planning meeting or being willing to pay a fee for water resource protection), conservation advocacy (e.g., participating in a volunteer event or joining a watershed organization, Stern 2000), and community organizing (Holley 2012).

Reliability is "the repeatability or replicability of findings. Instruments and procedures should produce the same results when applied to similar people in similar situations, or to the same people on a second occasion" (Sommer & Sommer 2002, p. 4).

Stakeholders are those who affect decisions, those affected by decisions, those with authority to enforce decisions, those who can block decisions, and those with relevant information or expertise.

Validity is “the degree to which a procedure produces genuine and credible information.” “Internal validity is the degree to which a procedure measures what it is supposed to measure. Is the operational definition consistent with other ways of identifying and measuring the behavior or characteristic?” “External validity refers to the generalizability of the findings. Do the results extend beyond the immediate setting or situation?” (Sommer & Sommer 2002, p. 4).

Target

The goal of the social measures monitoring system is to enable projects managers and staff to track the impact of their projects on community capacity to engage in water resource protection and restoration. The social measures monitoring system ultimately is aimed at increasing community capacity to engage in water resource protection and restoration. To do so, the system enables more strategic integration of social science measures into water project and program work plans. Project-specific indicators will be determined and coordinated by program staff and local project teams. For monitoring continuity and consistency, project-specific indicators, and targets should be based on social measures and core indicators. In turn, results can be aggregated. For example, on the social measures summary matrix (Figure 5) results falling in the moderately favorable, somewhat favorable or strongly favorable realm will be considered successful. When this target is met, programs will assume the overall goal of enhancing community capacity to engage in water resource protection and restoration is met. Identifying and incorporating local stakeholders’ criteria for success into water resource planning is critical to building community commitment for clean water projects (Davenport et al. 2010). As part of a civic engagement strategy, stakeholders may be asked to identify indicators and performance standards. Using participatory research and civic engagement methods, stakeholders can be encouraged to establish meaningful measures of success as they work toward water resource goals.

Baseline

The baseline will vary depending on indicator, watershed and community of focus.

Geographical Coverage

The social measures monitoring system may be applied at multiple scales using statewide, regional, watershed- or community-specific assessments. The monitoring tools also are effective at multiple scales, assuming sample size needs are considered. Agencies, programs and projects are working at multiple scales and thus the measures and tools must be readily scaled up and down.

Monitoring can also be scaled according to Priority Management Zones/Areas (PMZ/PMA), sentinel watersheds where interagency resources for complementary social data may be greatest, or subwatersheds where civic engagement strategies require a phased approach to PMZ/PMAs.

Data and Methodology

Methodology for Measure Calculation

Establish monitoring objectives

Project managers should establish clear social measures monitoring objectives before selecting project-specific indicators or assessment tools. Objectives should take into consideration (1) the community of focus in water resource protection and restoration and (2) the community's capacities (i.e., SM 1-5 and core indicators) that are significant to local engagement in water resource protection and restoration.

Select or develop project-specific indicators

Project managers are encouraged to select or develop their own project-specific indicators that are agency, project, and community relevant (e.g., stakeholders have adopted riparian buffers, diverse stakeholders have attended watershed planning meetings, organizations have increased community engagement in collaborative decision making). Project-specific indicators should be chosen that are specific, measurable, reliable and repeatable, sensitive to change, significant and relevant, and efficient (Figure 6). Using previously tested indicators can improve indicator reliability. Indicators measured in previous assessments can be found in published reports and in assessment instruments (e.g., survey questionnaire items, interview guide questions). However, selecting indicators that have been measured in previous assessments does not guarantee the indicators' reliability or sensitivity. Project managers should consult previous assessment project leaders to answer questions about indicator effectiveness.

Specific: Indicators should be specific so that when monitored, they can be attributed to a particular indicator and will demonstrate whether performance standards (i.e., minimally acceptable conditions) if appropriate are met.
Measurable: Indicators should be measurable using assessment tools. Data may be quantitative or qualitative and generalizable to a larger population or sample-specific.
Reliable and repeatable: Indicators should be selected that can be repeatedly measured and results will be similar regardless of who is monitoring.
Sensitive to change: Indicators should be sensitive to change over time and appropriately selected to be sensitive to management interventions. Indicators should provide early indication of constraints, incapacities, needs or problems within communities.
Significant and relevant: Indicators should be closely associated with community capacity to engage in water resource protection and restoration (refer to social measures). Indicators should be selected that relate to critical social measures and indicators in community capacity to engage in water resource programs and projects.
Efficient: Indicators should be selected in consideration of available resources (e.g. time, financial, expertise).

Figure 6. Characteristics of good project-specific indicators (adapted from Lime et al. 2004, Manning 1999)

Develop performance standards where appropriate
Project managers may also want to develop performance standards as thresholds of acceptability for appropriate indicators. This is likely best done after a baseline assessment of community capacity. Standards may vary agency to agency, watershed to watershed, or community to community. The standards should not be viewed as targets but rather as minimally acceptable conditions (e.g., 90% of shoreline owners have adopted riparian buffers). When minimally acceptable conditions are not met, management intervention is required. It is important to note that many community capacity indicators and project-specific indicators are complex and quantitative standards alone may not capture the full meaning, diversity and variability of capacities or constraints. For example, for SM1.1, awareness of water resource problems and consequences, it may seem appropriate to set a quantitative standard identifying the minimum average number of stakeholders attending a water resource problem informational meeting that is acceptable. However, focusing solely on *number* of meeting attendees does not consider the diversity of attendees and their representation of the community. Successful meetings are inclusive of particularly vulnerable or disadvantaged populations within the community. In this case, project-specific indicators might include standards of number and diversity of attendees. It is also important to consider quantity and quality when developing standards. Though number and diversity of meeting attendees tells a project manager who showed up, the real outcomes of the meeting are best measured by indicators and standards associated with the effect of the meeting on stakeholder awareness (SM1.1) and concern (SM1.2).

Project-specific indicators and performance standards (where appropriate) should be developed in collaboration with local project teams, program staff and local stakeholders. In some cases external consultants may be hired to help identify and prioritize indicators and indicators, depending on the project and responsible agency. Over time, a menu of sample (not prescribed or default) indicators and standards will be developed by compiling indicators, project-specific indicators and performance standards used successfully in Clean Water funded projects and activities.

Data Source
To date, no centralized database exists for social measures monitoring data. Currently data are available in published project reports and unpublished records of Clean Water Legacy Act (CWLA) watershed projects underway.

Data Collection Period
Data collection periods will vary by project based on project scope and purpose, monitoring objectives and resource availability.

Data Collection Methodology and Frequency
Each project will specify data collection method (i.e., assessment tool) and frequency based on project scope and purpose, monitoring objectives and resources available. Social measures assessments can be conducted at any time in a project for baseline understanding to inform design of civic engagement processes, outreach, education and other capacity-building activities; for engaging diverse stakeholders, checking in on progress and preliminary outcomes, and sharing knowledge; and for project outcomes monitoring, evaluation and adaptation. The data collection methodology (i.e., assessment tool selection) also will depend on the social measures (See Appendix A), core indicators and project-specific indicators selected for monitoring. Project managers should carefully consider the type of information generated, strengths and limitations of each assessment

tool (Table 1, Figure 6 and 7) when choosing assessment tools. Community capacity assessments may be conducted *pre-project* for baseline understanding of a community to inform communication, education, outreach and civic engagement programs or other capacity-building efforts. Assessments may be conducted *during the project* to check-in with and engage diverse stakeholders and share knowledge that can be used to adjust various components of the project. Assessments may be conducted *post-project* as part of a project monitoring, evaluation and adaptation process.

Select social assessment tools

Social measures monitoring is conducted using any one or combination of social assessment tools (Table 1, see Appendix B and C for resources and example approaches). Assessment tool selection will depend on the social measures, core indicators and project-specific indicators selected for monitoring. In addition, project managers should carefully consider the type of information generated, strengths and limitations of each assessment tool (Table 1).

Two primary considerations in social data collection are reliability and validity of measures. To increase reliability and validity, triangulation or the use of multiple observers/analysts, methods/tools, and data types (e.g., quantitative and qualitative) is recommended. Generalizability of results can be enhanced by using multiple monitoring sites and by increasing sample sizes (Sommer & Sommer 2002). An additional concern is ethics in social data collection (Sommer & Sommer 2002). Data collection personnel and analysts must take care to protect the welfare of human subjects. This is commonly done by making sure that participants are aware of the assessment/study objectives, procedures and any risks involved (i.e., full disclosure) and that participation is voluntary and participants can withdraw at any time(i.e., informed consent). Personnel might also want to protect participants' identity through maintaining confidentiality and/or anonymity. Confidentiality means only project personnel know the identity of the participant and that identity will not be publically available in published reports. Anonymity means that even project personnel do not know the identity of participants.

Social data are gathered using six primary assessment tools: participatory scoping, secondary data analysis, observation, focus groups, interviews, and surveys. Participatory scoping, including asset mapping and stakeholder or network analysis, is a method of gathering anecdotal information from people about an issue or project. Oftentimes issue scoping is used in conjunction with meetings or workshops as a way to informally gauge an audience's concerns and to encourage participation and relationship-building. Secondary data analysis is a process of compiling and synthesizing existing data, like U.S. census data, in a new way to enhance understanding of a community or a particular audience. Many assessments start with secondary data analysis to identify what is already known about a population. They can also help analysts inventory stakeholders and develop sociodemographic "profiles" of target audiences. However, published data are limited and may not be adequate for understanding human-water resource interactions (Morton & Padgitt 2005). Observation involves systematic documentation of observed human behavior, interactions in settings, or the effects of human behavior on the environment. In some cases, quantitative data are gathered through scoring systems developed a priori. Participant observation means that the analyst gathering data participates in the study community's activities or events to gain an insider perspective. Observation requires careful documentation of what people do, how often they do it and who is involved. Key informant interviews involve talking one-on-one with individual community members about their experiences, beliefs, attitudes and behaviors. Interviews elicit in-depth information about complex topics. Interviewing can answer why people engage in certain behaviors or how they make decisions to act. Focus groups are popular in marketing research, but focus groups can also be used to bring together a group of like-minded community members to discuss a particular water resource problem, opportunity or program in depth. Surveys are used to gather broad information from a large number of community members. Like popular opinion polls, surveys can tell you how many people or to what extent people within a population hold a belief or are likely to adopt a certain behavior.

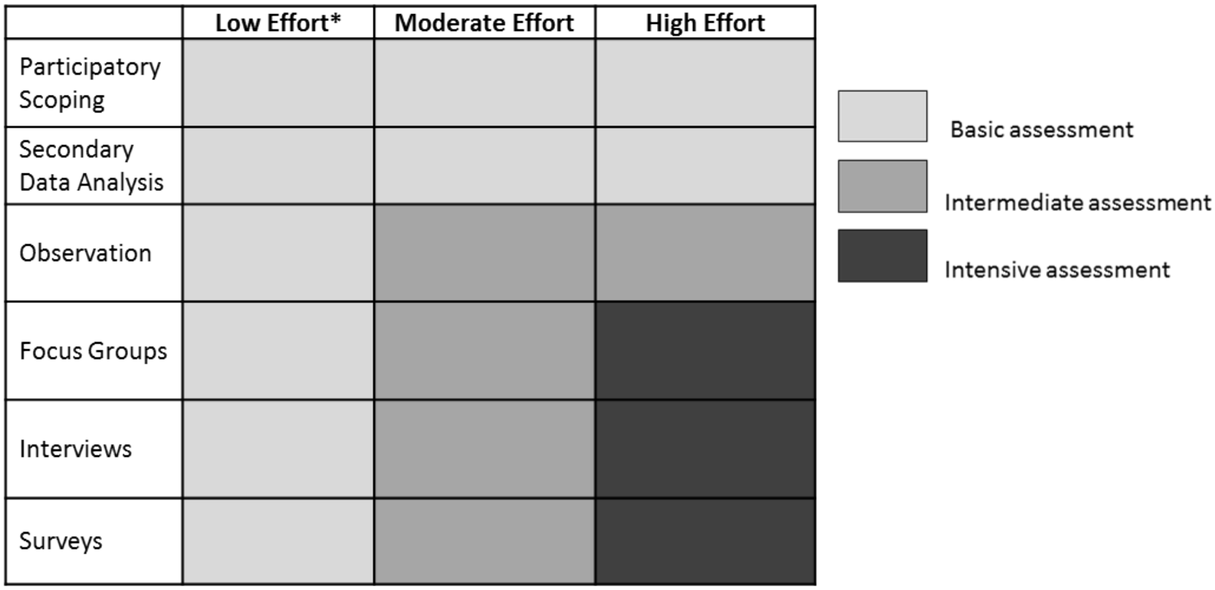
Monitoring will evolve in comprehensiveness and intensiveness. At the onset, it is likely that most monitoring efforts will be based on basic assessments with some intermediate and intensive assessments in specific watersheds/communities where resources are available (Figure 7). Intermediate and intensive assessments will become more commonly and comprehensively conducted as resources and expertise are developed over time, through increased project monitoring experience, intensified training and higher commitment of funds. Effective and efficient social measures monitoring will require capacity-building in agencies, programs and projects. Project managers may decide to contract with social scientists, extension agents, or other specialists with expertise in social assessment to conduct or provide technical assistance or training with assessments.

Table 1. Social assessment tools overview (adapted from Nickerson et al. 2006)

	Information gathered	Strengths	Limitations
Participatory Scoping	• Quantitative and qualitative information from purposively chosen or self-selected people • Often participatory accompanying group dialogue (e.g., stakeholder analysis, asset mapping, participatory mapping, issue framing, idea listing, nominal group processes, informal surveys) in workshops or meetings • Context- and issue-specific results not generalizable to larger population	• Explores new or little known issues • Allows for follow-up questioning and probing • New, unanticipated information can emerge • Low cost method • Relatively less staff time to administer • More immediate results • Can enable participants to get to know one another (e.g., foster relationship-building) • Can be conducted in a relatively short period of time (e.g., 2 hours or less)	• Can be time-intensive with large burden on participants, depending on design and implementation (e.g., 2 hours, plus travel) • Group dynamics, limited anonymity and confidentiality may influence participants • Results are largely subjective (e.g., may be issues with reliability) • Results are not generalizable to larger population • Data collection processes commonly do not follow standardized scientific methods
Secondary Data Analysis	• Primarily quantitative, socio-demographic data • Analysis of existing data	• Unobtrusive • Low-cost method • Standardized scientific methods exist for data collection	• Usually limited information available on specific issues • Scale may not be relevant • Can be time-intensive • May be less reliable depending on data source/methods
Observation	• Quantitative and qualitative data • Detailed information on observed behavior and settings • Answers "how much" and "how often"	• Usually unobtrusive • New, unanticipated information can emerge • Low cost method • Standardized scientific methods exist for data collection	• Can be time-intensive and require multiple personnel • Data documentation can be difficult • Requires staff expertise/training in observation and data analysis • Results are largely subjective and often require interpretation of what is seen (e.g., may be issues with reliability)
Interviews	• Primarily qualitative data from a small number of purposively	• Participant recruitment relatively easy with high participation rates	• Moderate burden on participants (e.g., 1 hour)

	chosen people • Participatory, naturalistic inquiry involving one-on-one dialogue • Detailed and in-depth information on a small number of issues • Thematic or content analysis of themes, patterns and relationships • Answers “why” and “what does it mean” • Context- and issue-specific results not generalizable to larger population	• Can be conducted in participants’ home workplace • Respondent identity can be confidential • Generates context- or issue-specific data • Allows for follow-up questioning and probing • Explores new or little known issues • New, unanticipated information can emerge • Low cost method • Relatively less staff time to administer • Standardized scientific methods exist for data collection	• May require payment/reimbursement to participants • Results are not generalizable to larger population • Can be time intensive to analyze • Requires staff expertise/training in interviewing and qualitative data analysis
Focus Groups	• Primarily qualitative data from a small number of purposively chosen people • Participatory, naturalistic inquiry involving group dialogue • Detailed and in-depth information on a small number of issues • Thematic or content analysis of themes, patterns and relationships • Answers “why” and “what does it mean” • Context- and issue-specific results not generalizable to larger population	• Generates context- or issue-specific data • Allows for follow-up questioning and probing • Explores new or little known issues • New, unanticipated information can emerge • Quick, relatively easy and low cost method • More immediate results • Relatively easy to organize and schedule • Relatively less staff time to administer • Can enable participants to get to know one another (e.g., foster relationship-building) • Standardized scientific methods exist for data collection	• Participant recruitment can be difficult • Relatively large burden on participants (e.g., 2 hours, plus travel) • Often requires payment/reimbursement to participants • Group dynamics, limited anonymity and confidentiality may influence participants • Results are not generalizable to larger population • Can be time intensive to analyze • Requires staff expertise/training in facilitation and qualitative data analysis
Surveys	• Primarily quantitative data from a large number of randomly	• Generates a broad data set on multiple issues	• Can be time-intensive and costly to design and administer

	chosen people • Broad information on a large number of issues • Statistical analysis of data (e.g., descriptive, comparisons, trend analysis, and hypothesis testing) • Answers "how much" and "to what extent" • Results generalizable to a larger population	• Results can be generalized to a larger population • Relatively small burden on participants (e.g., 20 minutes) • Can be administered by surveyor or self-administered (e.g., by mail, by phone, by e-mail, on internet, drop-off/pickup) • Respondent identity can be confidential and anonymous • Can make comparisons between subgroups and correlations between variables with statistical tests • Can provide a profile of population characteristics • Can be replicated over time to examine trends or effects of intervention (e.g., pre/post survey) • Standardized scientific methods exist for data collection	• Relatively large sample is needed • Response rates can vary • Non-response can bias results • Results largely dependent on quality/representation of sample drawn • Information gained is limited to questions/response options on questionnaire • Results are not immediate • Requires staff expertise/training in questionnaire design, sampling, and quantitative data analysis



*Effort levels reflect resources needed including expertise, cost, and time

Figure 7. Social measures monitoring system tiered approach with relative levels of effort

Supporting Data Set

To date, no centralized database exists for social measures monitoring. Currently social data are available in published project reports, unpublished CWLA project records, and, to a limited extent, publically available data sets (e.g., U.S. Census).

Future Improvements

The social measures monitoring system tiered approach (Figure 7) demonstrates that monitoring will evolve and intensify as capacities are built within agencies, programs and projects.

Building skills and understanding will require initial investment in technical assistance and training from social measures and social assessment experts. Early investments should include convening experts and practitioners in social science to conduct assessments independently or to partner with project teams to conduct cooperative assessments. Concurrently, investments should be made in convening experts and practitioners in training opportunities. Formalizing existing informal training forums and peer learning networks within and across agencies will facilitate knowledge, skill, and leadership development in social measures monitoring. Training staff is critical to the success of the social measures monitoring system. Each agency may have a unique approach to implementing and tracking the social measures. The strength of the framework is that it is systematic and flexible.

Financial Considerations

Developing and administering social measures monitoring methodologies which track changes over time in individual capacity and behaviors to protect and restore water resources will require additional financial investments from state and local government entities. Examples of investments may include

1) Development and honing of social science data collection and analysis methodologies to allow for gathering of credible and useful information for watershed managers and others addressing the social dimension of watershed projects.

2) Building knowledge and competency in social science monitoring and program evaluation within state and local government agency staff.

3) Consultation with professionals that can provide expertise to support this effort in areas such as of social science monitoring and program evaluation.

4) Creation of databases necessary to manage the data that are collected from projects across the state.

Social science data collection and program evaluation are evolving areas of practice within the field of watershed management. Investments in this work are likely to begin slowly and increase as the need for information and trend analysis data is recognized. It is advisable to take a phased approach to rolling out any new monitoring or program evaluation systems to support grounded and informed decisions that will support long-term institutional and program capacity building in this arena.

Measure Points of Contact

Agency/Affiliation Information

Social Measures Team Members
Margaret Wagner (Chair)
Minnesota Department of Agriculture
Margaret.wagner@state.mn.us
651-201-6488

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

Tannie Eshenaur
Minnesota Department of Health
tannie.eshenaur@state.mn.us

Katherine Logan
Minnesota Pollution Control Agency
katherine.logan@state.mn.us

Barb Radke
Board of Soil and Water Resources
barbara.radke@state.mn.us

Sharon Pfeifer
Minnesota Department of Natural Resources
sharon.pfeifer@state.mn.us

Preparer
Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

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Appendices

Appendix A: SM1-5 Metadata Sheets

Social Measure 1: Change over time in individual capacity to engage in water resource protection and restoration[1]

Measure Background

Social Measure (SM) 1, *change over time in individual capacity to engage in water resource protection and restoration*, has four overarching goals. SM1 is designed to enable project managers to (1) assess and track over time a community's individual capacity to engage in water resource protection and restoration and (2) evaluate effects of water resource education, outreach and civic engagement programs on individual capacity. Monitoring individual capacity also will help water resource project managers and community leaders (3) identify and address constraints to individual capacity and (4) maintain and build individual capacity. **A community's individual capacity is defined as an individual's knowledge, beliefs, norms, attitudes and abilities that altogether contribute to pro-environmental behavior associated with water resource protection and restoration**. SM1 has nine core indicators (Figure 1) and can include multiple project-specific indicators (see Social Measures Monitoring System Overview: Appendix A for Project-Specific Indicator Sample Sets).

Core Indicators of Individual Capacity

1. **Awareness** of water resource problems and consequences
2. **Concern** about water resource problems and consequences
3. Perceived **control** and **efficacy** in water resource protection and restoration
4. **Personal sense of responsibility** for water resource problems, consequences and solutions
5. **Personal norms** of pro-environmental behavior
6. Perceived **social norms** of pro-environmental behavior
7. **Beliefs** about and **attitudes** toward water resource protection and restoration
8. **Ability** (i.e., knowledge, skills and resources) to engage in pro-environmental behavior
9. Pro-environmental **behavior** (i.e., individual/private actions and collective/public actions) associated with water resource protection and restoration

Figure 1. SM1 core indicators

In the last decade an increasing amount of social data has been gathered to inform water resource management in Minnesota. However, past assessments have been predominantly site-specific or project-specific case studies and most have used survey tools. Many past data collection efforts have lacked science-based or standardized measures to enable meaningful comparison or the potential for aggregation. Furthermore, there has been no systematic effort to compile or synthesize this information to date.

Most monitoring has focused on individual capacity, and in particular human awareness, beliefs and behaviors. Some of this work has been conducted by local units of government for whom gathering

[1]Please refer to the Social Measures Monitoring System Overview document for general information about the five social measures and a definition of terms and concepts used in individual metadata sheets.

"public input" is required in the development of water management plans (i.e., local water management plans). Several local water management plans have included assessments of "priority concerns" most commonly identified through an issue scoping process or by administering a public priority issues survey. Other assessments have been conducted in watersheds that have experienced water resource problems or are particularly vulnerable to water resource problems in the future.

A few statewide assessments have been conducted with relevance to individual capacity for water resource protection and restoration. The Minnesota Report Card on Environmental Literacy (Murphy & Olson 2008) details a statewide assessment of individual capacity indicators knowledge, beliefs and attitudes associated with water quality and water pollution regulations. Statewide mail surveys of registered anglers have examined beliefs, attitudes and behaviors associated with fisheries management (Bruskotter & Fulton 2008). More recently, Clean Water Land and Legacy funds supported a statewide assessment of farmer behaviors associated with nitrogen fertilizer use (Bierman et al. 2011).

Some recent watershed scale studies of individual-level capacity have investigated additional indicators including awareness, concern, responsibility, social norms, and ability (Davenport & Pradhananga 2012, Eckman et al. 2011, Nerbonne et al. 2006, Davenport & Olson 2013, Pradhananga & Davenport 2013, Rausch 2009). Recent program evaluation studies have assessed the effects of management interventions (e.g., outreach and education programs) on knowledge, beliefs and behaviors toward water resources (Eckman & Blickenderfer 2012; Eckman & Henry 2012).

Measure Description

SM1 *change over time in individual capacity to engage in water resource protection and restoration* is grounded in social science theory in the fields of psychology, sociology, community development and public health (Chaskin et al. 2001, Foster-Fishman et al. 2001, Goodman et al. 1998); empirical research conducted in Minnesota and across the U.S.; and ongoing dialogue with water resource professionals and policy-makers in the Midwest. The recently published Multilevel Community Capacity Model (MCCM) for sustainable watershed management (Davenport & Seekamp 2013) provides a broad framework for monitoring and evaluating individual capacity to engage in water resource protection and restoration. This measure provides data to identify where to focus community capacity-building or where to target communication, education outreach and civic engagement programs. In this model "member capacity[2]" refers to community members' knowledge and beliefs, awareness and concern, sense of personal responsibility and perceived control associated with water resource problems and their consequences. Altogether these capacities contribute to engagement in pro-environmental behaviors including private-sphere (e.g., land use practices) and public-sphere (e.g., civic engagement) actions.

SM1's nine core indicators (Figure 1) draw heavily upon three primary theories of human behavior: theory of planned behavior (Ajzen 1991), norm-activation theory (Schwartz 1977), and value-belief-norm theory (Stern 2000).

[2] Davenport & Seekamp (2013) refer to member capacity with respect to community member capacity to engage in sustainable watershed management. SM1 uses instead the term "individual capacity" but the two capacity levels are parallel.

Understanding what *motivates* people is central to increasing pro-environmental behaviors (Manning 2009, Schultz 2011). While previous interventions to promote conservation have focused on rational decision making processes influenced by external forces (e.g., education, financial incentives, and regulations), SM1 provides a more holistic measure of behavior that includes behaviors that are rationally driven, morally driven and socially driven.

Nine core indicators have been developed for SM1:

- ***Awareness*** refers to the state of knowledge or realization of a water resource problem or need and its consequences. Awareness requires some level of prominence, clarity, and an individual's receptivity to the need (Schwartz 1977).
- ***Concern*** is driven by individual value orientations[3] or basic beliefs about human relationships with the environment (i.e., biospheric concern), with others (i.e., altruistic concern) and with the self (i.e., egoistic concern, Stern & Dietz 1994). Concern can vary by the perceived level of seriousness or intensity (Schwartz 1977) of the problem or need.
- ***Perceived control*** *and* ***efficacy*** are important drivers of pro-environmental behavior. Efficacy refers to perceptions that certain actions (i.e., behaviors) will address the water resource problem or relieve the need. Perceived control requires the perception that one has the ability to act. It is important to note that perceived ability and actual ability are not always parallel.
- ***Responsibility*** is the recognition of having a duty or civic obligation to engage in actions that address the water resource problem or need. Responsibility requires a sense of connection to water resources which may be in the form of a recognized relationship with water, a sense of usefulness to improving its condition, or being "causally connected" (i.e., knowing personal actions contributed to the water resource problem). Emergencies or crisis events can also prompt a sense of responsibility (Schwartz 1977, p. 246).
- ***Personal norms*** are internal pressures or self-expectations to act based on one's deeply held cultural and environmental values, a feeling of moral obligation, and in some cases, anticipated guilt (Schwartz 1977, Thogersen 2006). Personal norms drive behavior that is not directly self-benefiting like pro-social behavior (e.g., helping others) and pro-environmental behavior.
- ***Perceived social norms,*** according to Cialdini and Trost (1998), refer to "rules and standards that are understood by members of a group, and that guide and/or constrain social behavior without the force of laws" (p. 152). The influence of social norms or social pressures on individuals, including what others do and what others think one should do, largely happens subconsciously, without much effortful thinking. Social norms are based on external pressures from society, important social groups, friends and family. Morton (2008) found that social norms of pro-environmental behavior in an agricultural community contributed to positive social and water resource outcomes.
- ***Beliefs and attitudes*** toward pro-environmental behavior (i.e., water resource protection and restoration) are opinions about (1) the likelihood that a particular behavior or action

[3] Values are defined as basic beliefs about the relationship between people (i.e., cultural values) and between people and the environment (i.e., environmental values). Many behavioral theoretical models (e.g., value-belief-norm model) identify values as the foundation of higher order beliefs, attitudes and behaviors. However, values are believed to be deep-seated and difficult to change and thus, are not included as a core indicator in SM1.

will produce an outcome and (2) the costs and benefits of the outcome (i.e., negative or positive evaluations, Ajzen 1991).

- ***Ability*** is tied to possessing or being able to access resources including knowledge, skills, equipment, financial resources, technical ability and infrastructure (e.g., public transportation) needed to engage in pro-environmental behaviors.
- ***Pro-environmental behaviors*** are broadly defined and encompass private-sphere actions like land and water use conservation (e.g., rain garden installation and the maintenance of streamside buffers), as well as public-sphere actions like conservation citizenship (e.g., attending a watershed planning meeting or being willing to pay a fee for water resource protection), conservation advocacy (e.g., participating in a volunteer event or joining a watershed organization, Stern 2000), and community organizing (Holley 2012).

Visual Depiction

Visual depictions of SM1 will vary depending on the monitoring tool and the type of data (i.e., quantitative, qualitative, spatial) gathered. Quantitative data output may be displayed as descriptive statistics, frequency tables, and graphics (e.g., bar/pie charts, spatial analysis maps). Qualitative data output may consist of direct quotes, theme tables, and graphics (e.g., concept maps, decision frameworks). Example data outputs are provided below (Figures 2-7, Tables 1-4).

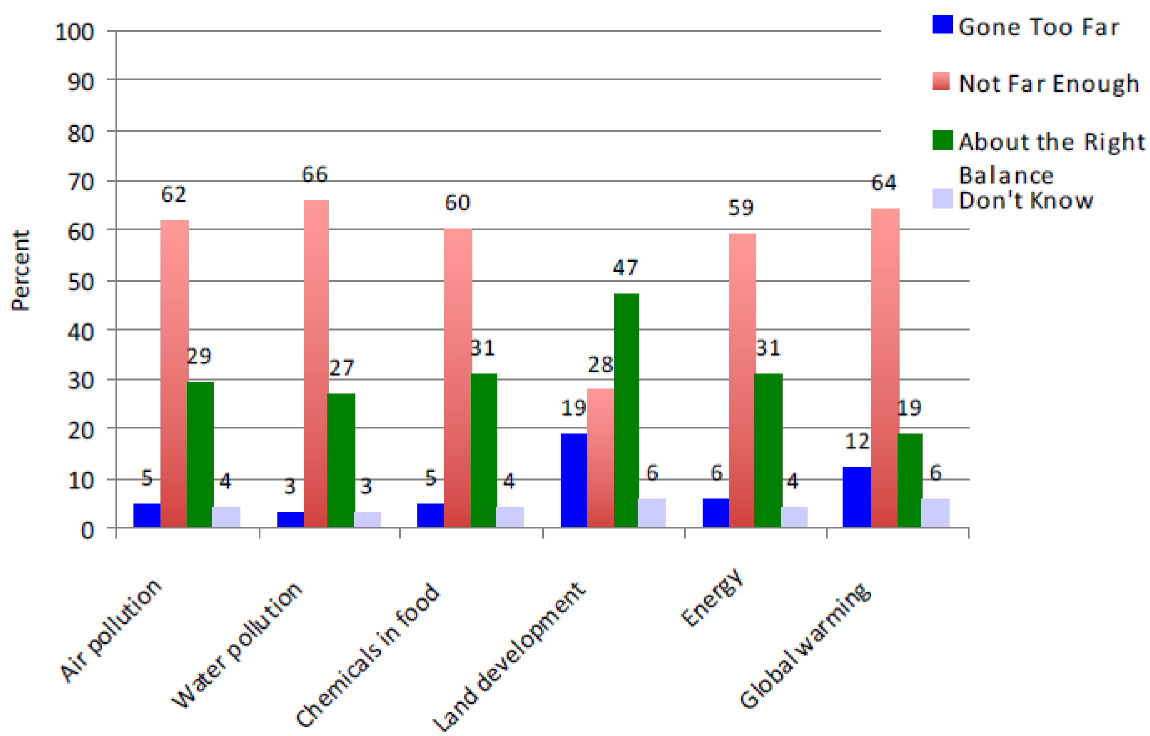

Figure 2. Percentage of Minnesotans who think that the environmental laws and regulations for specific environmental topics have gone too far, have not gone far enough, and have struck about the right balance (Murphy & Olson 2008)

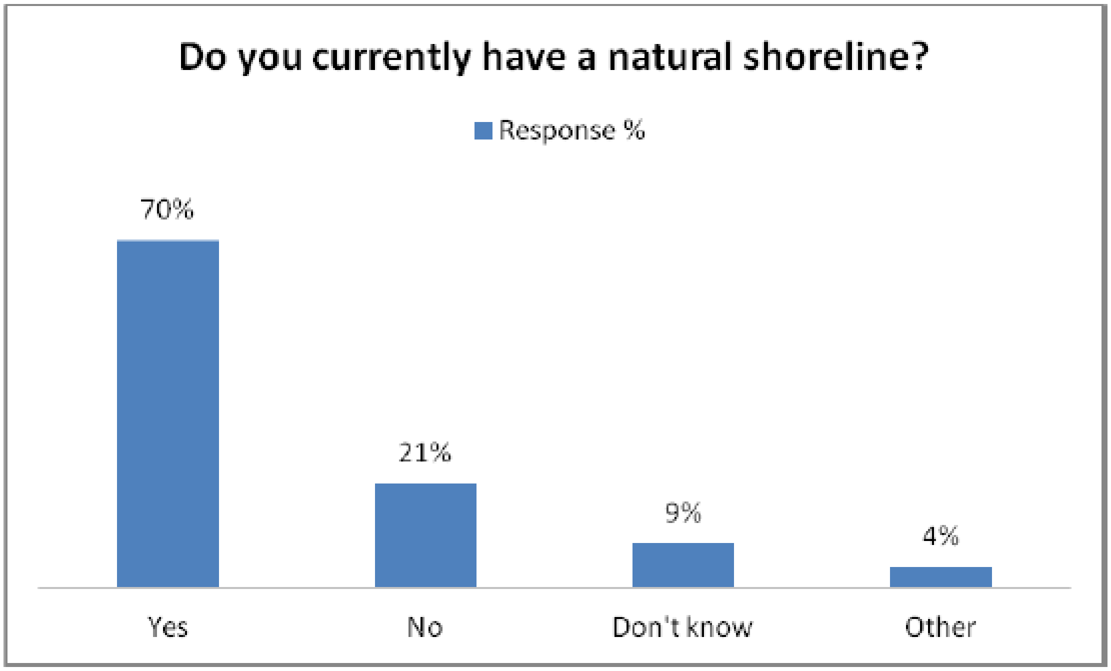

Figure 3. Percentage of East Otter Tail County respondents reporting having a natural shoreline (Eckman & Henry 2012)

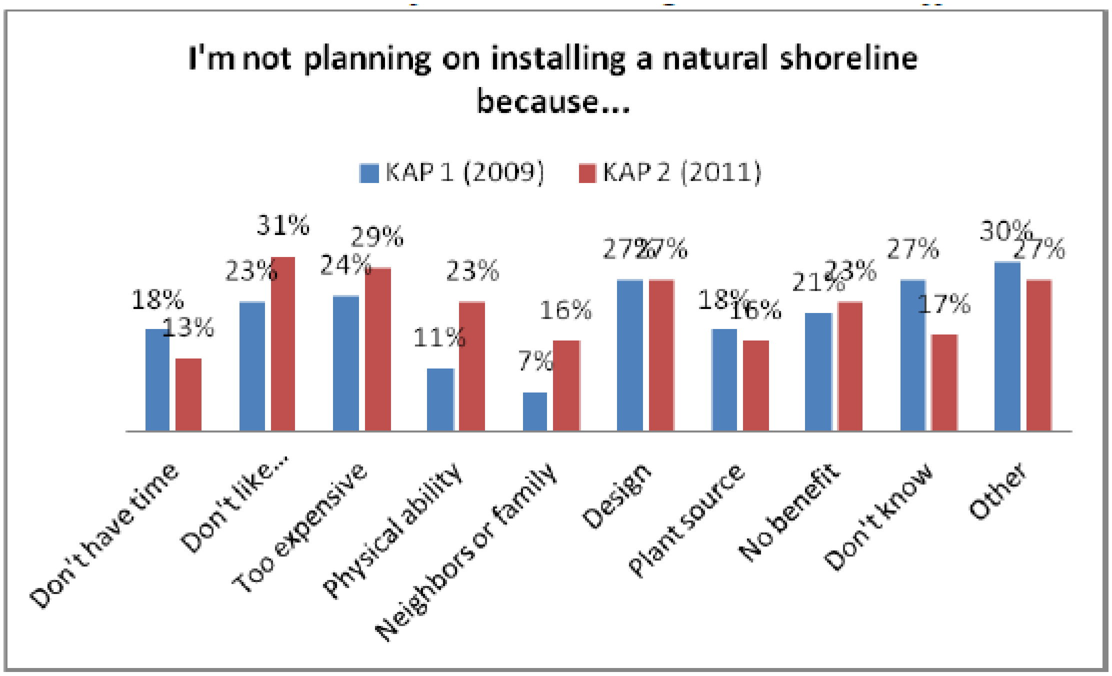

Figure 4. Reasons East Otter Tail County respondents gave for not installing a shoreland buffer (Eckman & Henry 2012)

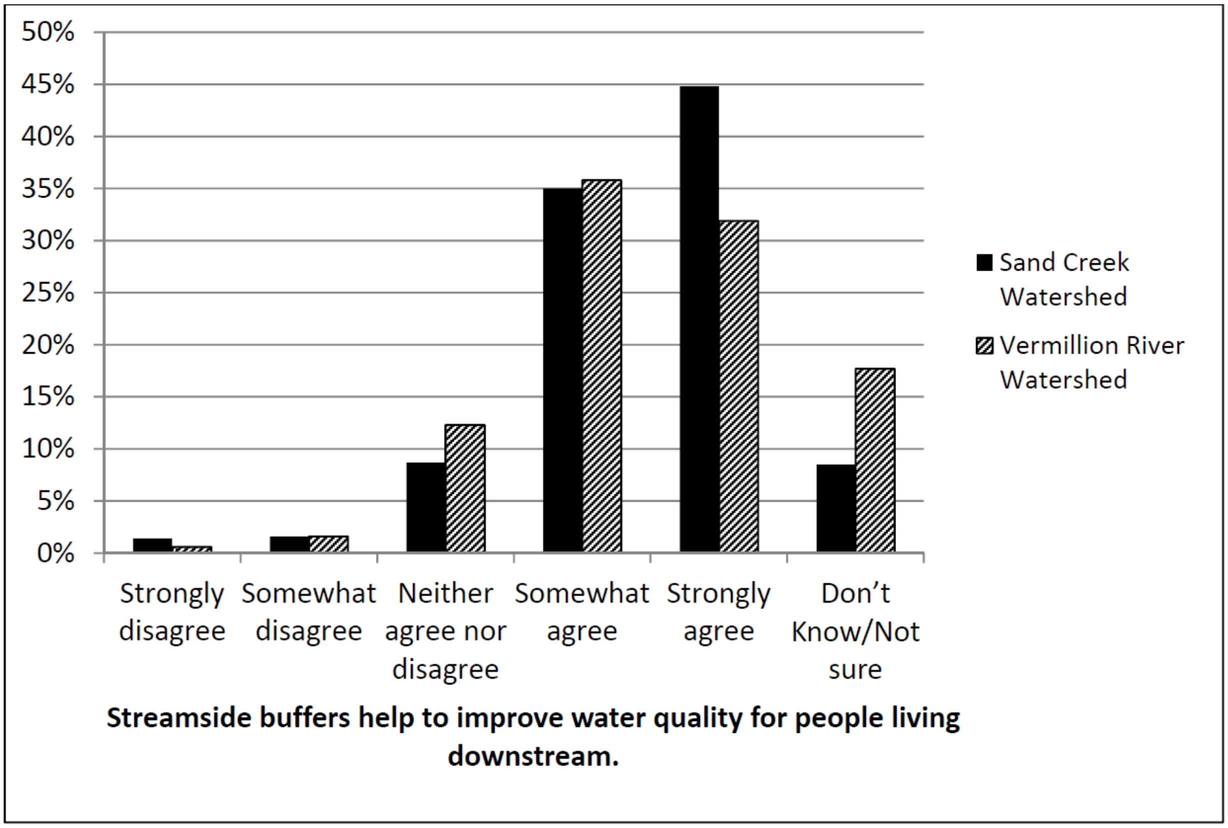

Figure 5. Sand Creek and Vermillion River watershed respondent reported level of agreement with the statement "streamside buffers help to improve water quality for people living downstream" (Davenport & Pradhananga 2012)

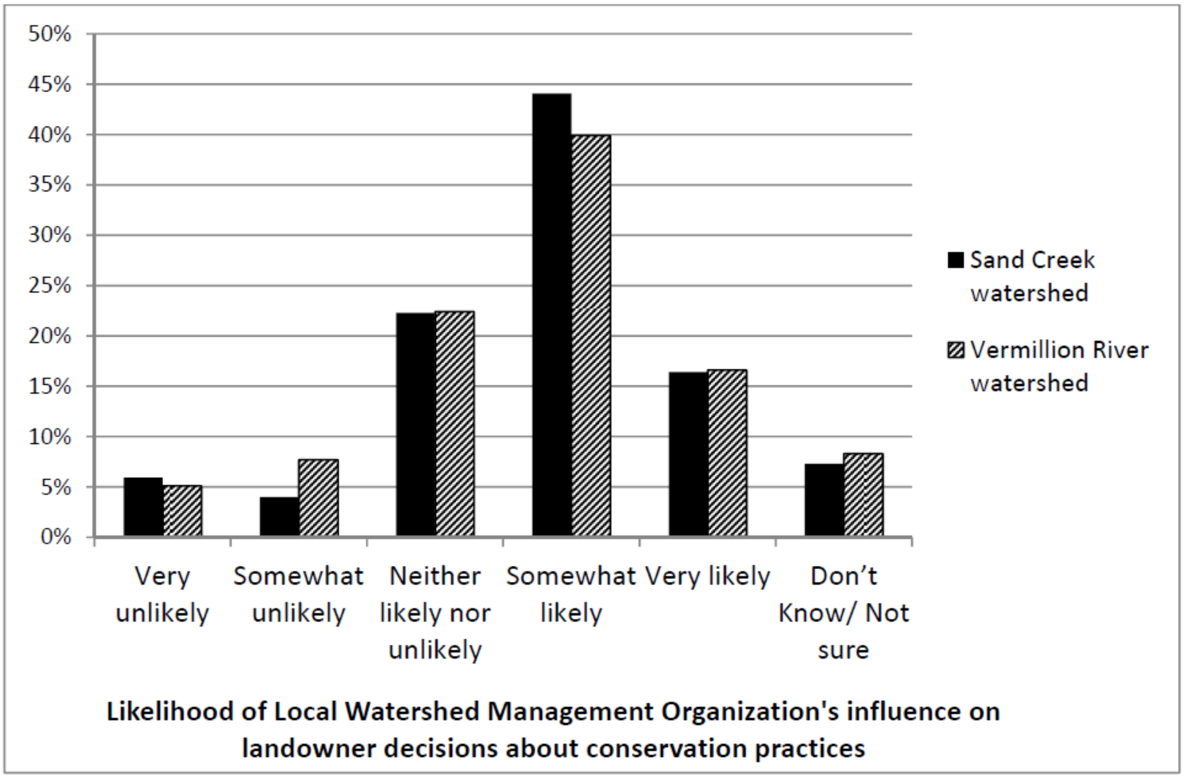

Figure 6. Sand Creek and Vermillion River watershed respondent reported likelihood of local watershed management organization's influence on their decisions about conservation practices (Davenport & Pradhananga 2012)

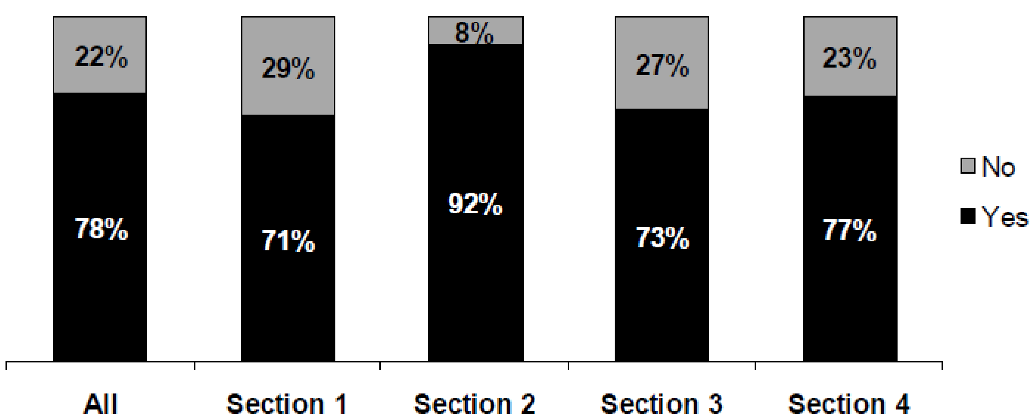

Figure. 7. Capitol Region Watershed District resident respondent willingness to pay a $3.00 property tax increase to protect water quality (Rausch 2009)

Table 1. Duluth watershed respondent response to "what is the name of the stream in your neighborhood?" (Eckman et al. 2011)

	2008 baseline survey (all respondents) $n = 63$	2010 (control respondents) $n = 46$	2010 (treatment respondents) $n = 17$
Able to name Amity Creek	13 (21%)	14 (30%)	6 (40%)
Able to name the Lester River	15 (24%)	4 (9%)	3 (20%)
Able to name both Amity and Lester	2 (3%)	7 (15%)	3 (20%)
Not sure	7 (11%)	6 (13%)	2 (13%)
Unable to name any stream or river	25 (40%)	12 (19%)	0
Other	1 (2%)	3 (6%)	1 (6%)

Table 2. Minnehaha Creek watershed study participant reported member constraints to community engagement in water resource protection and restoration (Pradhananga & Davenport 2013)

Category	Theme *Descriptors*	FD*	ANMCM	AMCM
Understanding	**Lack of awareness** *Community members lack awareness of water resource problems and their own connection to water*	x	x	x
	Limited knowledge *Lack of information and limited knowledge about water resource issues*	x	x	x
Beliefs and attitudes	**Perceptions of water resources** *Water quality is difficult to define; some members have negative perceptions of creek (i.e., as "a swamp")*	x	x	x
	Focus on other issues *Community pays more attention to other issues such as media entertainment than water resource issues*		x	
	Lack of motivation to be involved *Some community members perceive that there is no reason to be involved in water resource issues; lack of a "burning platform;" renters and the private sector are not as engaged as homeowners in water issues*	x	x	x
	Narrow self-interest *Some community members focus only on self-interests in water resource issues*	x	x	x
	Idealism over pragmatism *Individuals who focus on big changes do not understand slow, incremental changes needed for water resource restoration*	x		
Social norms	**Social norms** *Community members are constrained by social expectations like "the culture of shiny green lawns"*		x	
Responsibility	**Diffusion of responsibility** *Community members perceive that it is government responsibility to take care of water resource issues*		x	x
Ability	**Lack of time** *Community members have other priorities that take up most of their time*	x		X
	Lack of efficacy *Some community members believe that they are unable to do anything about water resource issues*	x	x	

*Participant stakeholder group affiliation (FD: formal decision makers, ANMCM: active non-minority community members, AMCM: active minority community members); an "x" indicates at least one participant in the stakeholder group identified the theme.

Table 3. Rush River and Elm Creek farmer study rankings of BMPs across adoption factors (Davenport & Olson 2012)

BMP	Overall likelihood of adoption[a]	Current adoption[b]	Farmer familiarity[c]	Ease of adoption[d]	Crop impact[e]	Landscape suitability[f]
Buffer/filter strips	1	1	1*	3	4	3
UMN recommendations for nitrogen application	2	2	6*	1	3	2
Variable rate technology	3	3*	6*	2	1	1
Cover crops	4	3*	1*	5	7	6
Alfalfa	5	3*	1*	6	8	4
Controlled drainage	6	6*	6*	8	2	10
Bioreactors	7	9*	9	4	5	7
Wetlands	8	6*	1*	10	9	9
Two-stage ditch	9	9*	10	9	6	8
Alternative energy	10	8	1*	7	10	5

[ŧ] Analysis of qualitative data using a 1-10 ranking system (1=highest relative likelihood of adoption/maintenance)

[a] A summary ranking of likelihood of adoption/maintenance based on adoption factors [b-f]

[b] BMP adoption (1=adopted by highest number of participants), based on question 19, see Table 14

[c] Familiarity with BMP (1=familiar to the highest number of participants), based on question 20, see Table 15

[d] Perceived ease of BMP adoption (1=easiest to adopt), based on questions 19e and 20b, see Table 12

[e] Perceived BMP impact on crop (1=<u>least</u> impact to crops), based on questions 19e and 20b, see Table 12

[f] Perceived landscape suitability for BMP (1=most suitable for landscapes), based on questions 19e and 20b, see Table 12

*Indicates a tie

Table 4. Longfellow/Seward participant responses to general issues of concern, concern for water quality in the home, and concern for the Mississippi River (Nerbonne et al. 2006)

Inter-viewee	Environmental Attitude	Environmental Issues	H2O Quality at Home	H2O Quality in River	Is the River Improving?
1	Low	none	fair	polluted	unknown
2	Low	resources, pollution, energy	good	fertilizer	unknown
3	Low	air, rainforest	good	polluted	yes
4	Low	development but not env.	good	polluted	no
5	Low	pollution - industries	fair	polluted	yes
6	Low	air, energy	fair	animal runoff	unknown
7	Low	transportation, consumption	okay		
8	Low	animals, yard waste	good	polluted	maybe
9	Low	buckthorn, Mississippi river	good	fertilizer runoff	maybe
10	Low	litter, air	god	polluted	yes
11	High	pollution	poor	mercury	yes
12	High	energy	good	unknown	unknown
13	High	Mississippi river, air, pollution	poor	runoff - industrial	maybe
14	High	water, development	good	runoff - urban, invasives	yes
15	High	air, energy	good	fertilizer runoff	yes
16	High	pollution, energy, water	okay	runoff - industrial	yes
17	High	development, consumption	good	runoff - industrial	maybe
18	High	pollution	poor	road runoff	no
19	High	pollution, global warming	okay	fertilizer runoff, chemicals	maybe
20	Elite	energy	okay	runoff - industrial, farms	no
21	Elite	energy	good	runoff - urban, chemicals	maybe
22	Elite	water, runoff	okay	runoff - urban, fert., chem.	yes

Target

The overarching goal for water resource projects is to enhance community capacity to engage in water resource protection and restoration. Specifically, projects should support and enhance the ability of individuals and communities to get clean water work completed. For SM1 the goal is to track and enhance individual capacity to engage in water resource protection and restoration. More specifically, SM1 targets should include

- Increasing awareness and concern about water resource problems and consequences
- Promoting perceived control and efficacy in water resource protection and restoration
- Developing personal sense of responsibility for water resource problems, consequences and solutions
- Fostering personal norms and perceived social norms of pro-environmental behavior
- Encouraging positive beliefs about and attitudes toward water resource protection and restoration
- Providing resources that remove constraints and enhance abilities to engage in pro-environmental behaviors
- Inspiring pro-environmental behavior associated with water resource protection and restoration

There is no specific quantitative target for this measure. In the social measures monitoring system, project-specific outcomes indicators, outputs (i.e., products and services), performance standards (i.e., minimally acceptable conditions), and targets will be determined and coordinated by program staff and local project teams. For monitoring continuity and consistency of SM1, indicators, outputs, standards, and targets should be based on SM1 and its nine core indicators. Identifying and incorporating local stakeholder criteria for success into water resource planning is critical to building community commitment for clean water projects (Davenport et al. 2010). In certain areas, stakeholders may be asked to identify indicators, outputs, performance standards, and targets. Using participatory research and civic engagement methods, stakeholders can be encouraged to establish meaningful measures of success as they work toward water resource goals.

Baseline

The baseline will vary depending on indicator, watershed and community of focus.

Geographical Coverage

The social measures monitoring system may be applied at multiple scales using statewide, regional, watershed- or community-specific assessments. The monitoring tools also are effective at multiple scales, assuming sample size needs are considered. Agencies, programs and projects are working at multiple scales and thus the measures and tools must be readily scaled up and down.

Monitoring can also be scaled according to Priority Management Zones/Areas (PMZ/PMA), sentinel watersheds where interagency resources for complementary social data may be greatest, or subwatersheds where civic engagement strategies require a phased approach to PMZ/PMAs.

Data and Methodology

Methodology for Measure Calculation

A range of assessments will be conducted in specific subwatersheds and with specific communities that have experienced water resource problems or are particularly vulnerable to water resource problems. Assessments also will be conducted in priority areas for water resource protection.

SM1 monitoring will be conducted using any one or combination of standard social science assessment tools (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7).

Data Source

To date, no centralized database exists for social measures monitoring. Currently data are available in published project reports and unpublished records of Clean Water Legacy Act (CWLA) watershed projects underway.

Data Collection Period

Data collection periods will vary by project based on project scope and purpose, monitoring objectives and resource availability.

Data Collection Methodology and Frequency

Each project will specify data collection method (i.e., assessment tool) and frequency based on project scope and purpose, monitoring objectives and resources available. Social measures assessments can be conducted at any time in a project for baseline understanding to inform design of civic engagement processes, outreach, education and other capacity-building activities; for engaging diverse stakeholders, checking in on progress and preliminary outcomes, and sharing knowledge; and for project outcomes monitoring, evaluation and adaptation. The data collection methodology (i.e., assessment tool selection) also will depend on the social measures, core indicators and project-specific indicators selected for monitoring (see Social Measures Monitoring System Overview: Appendix A). Project managers should carefully consider the type of information generated, strengths and limitations of each tool (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7) when choosing assessment tools.

Supporting Data Set

To date, no centralized database exists for SM1. Currently social data are available in published project reports, unpublished CWLA project records and, to a limited extent, publically available data sets (e.g., U.S. Census).

Future Improvements

The social measures monitoring system tiered approach (see Social Measures Monitoring System Overview: Figure 7) demonstrates that monitoring will evolve and intensify as capacities are built within agencies, programs and projects.

Building skills and understanding will require initial investment in technical assistance and training from social measures and social assessment experts. Early investments should include convening experts and practitioners in social science to conduct assessments independently or to partner with project teams to conduct cooperative assessments. Concurrently, investments should be made in convening experts and practitioners in training opportunities. Formalizing existing informal training forums and peer learning networks within and across agencies will facilitate knowledge, skill, and leadership development in social measures monitoring. Training staff is critical to the success of the social measures monitoring system. Each agency may have a unique approach to implementing and tracking the social measures. The strength of the framework is that it is systematic and flexible.

Financial Considerations

Developing and administering social measures monitoring methodologies which track changes over time in individual capacity and behaviors to protect and restore water resources will require additional financial investments from state and local government entities. Examples of investments may include

1) Development and honing of social science data collection and analysis methodologies to allow for gathering of credible and useful information for watershed managers and others addressing the social dimension of watershed projects.

2) Building knowledge and competency in social science monitoring and program evaluation within state and local government agency staff.

3) Consultation with professionals that can provide expertise to support this effort in areas such as of social science monitoring and program evaluation.

4) Creation of databases necessary to manage the data that are collected from projects across the state.

Social science data collection and program evaluation are evolving areas of practice within the field of watershed management. Investments in this work are likely to begin slowly and increase as the need for information and trend analysis data is recognized. It is advisable to take a phased approach to rolling out any new monitoring or program evaluation systems to support grounded and informed decisions that will support long-term institutional and program capacity building in this arena.

Measure Points of Contact

Agency/Affiliation Information

Social Measures Team Members
Margaret Wagner (Chair)
Minnesota Department of Agriculture
Margaret.wagner@state.mn.us
651-201-6488

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

Tannie Eshenaur
Minnesota Department of Health
tannie.eshenaur@state.mn.us

Katherine Logan
Minnesota Pollution Control Agency
katherine.logan@state.mn.us

Barb Radke
Board of Soil and Water Resources
barbara.radke@state.mn.us

Sharon Pfeifer
Minnesota Department of Natural Resources
sharon.pfeifer@state.mn.us

Preparer

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

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Social Measure 2: Change over time in relational capacity to engage in water resource protection and restoration[1]

Measure Background

Social Measure (SM) 2, *change over time in relational capacity to engage in water resource protection and restoration,* has four overarching goals. SM2 is designed to enable project managers to (1) assess and track over time a community's relational capacity to engage in water resource protection and restoration and (2) evaluate effects of water resource outreach, education and civic engagement programs on relational capacity. Monitoring relational capacity also will help water resource project managers and community leaders (3) identify and address constraints to relational capacity and (4) maintain and build relational capacity. Relational capacity is a set of community resources created through human interactions and relationships**. A community's relational capacity encompasses strong social networks and positive interpersonal relationships within communities that promote information exchange; build trust; foster shared identity; and promote common awareness, concern and sense of responsibility for water resources. Ultimately, collective action in water resource protection and restoration depends on relational capacity.** SM2 has eight core indicators (Figure 1) and can include multiple project-specific indicators (see Social Measures Monitoring System Overview: Appendix A for Project-Specific Indicator Sample Sets).

Core Indicators of Relational Capacity

1. Inclusive **social networks** for knowledge and information exchange
2. Social **connectedness** and **trust**
3. **Shared identity**
4. **Diversity is valued**
5. Positive **social interactions** and **conflict management**
6. **Common awareness and concern** about water resource problems
7. **Mutual sense of responsibility** for water resource problems, consequences, and solutions
8. **Collective action** associated with water resource protection and restoration

Figure 1. SM2 core indicators

In the last decade an increasing amount of social data has been gathered to inform water resource management in Minnesota. However, past assessments have been predominantly site-specific or project specific case studies and most have used survey tools. Many past data collection efforts have lacked science-based or standardized measures to enable meaningful comparison or aggregation. Furthermore, there has been no systematic effort to compile or synthesize this information to date.

[1] Please refer to the Social Measures Monitoring System Overview document for general information about the five social measures and a definition of terms and concepts used in individual metadata sheets.

While most monitoring has focused on individual beliefs and behaviors, some more indepth studies have examined indicators associated with relational capacity including social networks, social norms, mutual sense of responsibility and collective action. A few recent Minnesota assessment projects have relevance to relational capacity for water resource protection and restoration. For example, social networks, connectedness and trust, and shared identity have been explored using focus group and interview assessment tools in agricultural communities (Lewandowski 2010), culturally diverse urban communities (Mississippi Watershed Management Organization & City of Minneapolis 2007, Pradhananga & Davenport 2013), and among private forest landowners (Kueper et al. 2013). Other survey-based studies have measured social norms and the influence of others on conservation decision making (Eckman & Blickenderfer 2012, Davenport & Pradhananaga 2012). A few studies have investigated mutual sense of responsibility for water resource problems (Davenport & Pradhananga, Nerbonne & Schreiber 2005) and engagement in collective or public action (Bruskotter & Fulton 2008, Davenport & Pradhananga 2012, Eckman & Blickenderfer 2012, Eckman & Henry 2012).

Measure Description

SM2 *change over time in relational capacity to engage in water resource protection and restoration* is grounded in social science theory in the fields of psychology, sociology, community development and public health (Chaskin et al. 2001, Foster-Fishman et al. 2001, Goodman et al. 1998); empirical research conducted in Minnesota and across the U.S.; and ongoing dialogue with water resource professionals and policy-makers. The Multilevel Community Capacity Model (MCCM) for sustainable watershed management (Davenport & Seekamp 2013, Figure 1) provides a broad framework for monitoring and evaluating relational capacity to engage in water resource protection and restoration**.** This measure provides data to identify where to focus community capacity-building or where to target communication, education outreach and civic engagement programs. In this model "relational capacity" is described as informal social networks; sense of community based on shared identity, social cohesion and trust; common awareness and concern; and collective sense of responsibility.

The eight core indicators of SM2 (Figure 1) draw upon several social science constructs described below.

- ***Social networks, connectedness and trust***—what social scientists broadly refer to as "social capital" (Coleman 1988)—are critical components of human relationships and building blocks of collective action (Pretty and Ward 2001). Linkages within and between individuals, local groups and external agencies/institutions increase knowledge and information exchange (e.g., through knowledge networks), as well as enhance skill-building (Kueper et al. 2013). They can also serve to establish social norms of behavior and pressures on "norm violators" (Coleman 1988). Communities with high social connectedness and trust between members are more likely to work together and achieve positive outcomes (Morton 2008).
- ***Identity*** is defined as "a way of describing an individual that locates him or her within a social and political context" (Clayton 2012, p. 164). Identities are important in both connecting individuals to others and distinguishing individuals from others. Identities describe personal characteristics, define social groups, and motivate behavior. Shared community or environmental identities (e.g., farming community, lake community, kayaking community) can promote social connectedness and trust and increase collective action.

- ***Valuing diversity*** including diverse cultures, lifestyles and ideas contributes to relational capacity (Foster-Fishman et al. 2001, Pradhananga & Davenport 2013). Foster-Fishman et al. (2001) argue that to be effective, community coalitions should be inclusive and representative of the community including diverse community roles (e.g., business owners, elected officials, faith-based leaders, residents) and socio-demographic groups (e.g., gender, age, income, race and ethnicity, ability).
- ***Social interactions*** and appropriate mechanisms for ***conflict management*** (Goodman et al. 1998) are important conditions for relational capacity, especially when different values and interests collide.
- ***Common awareness*** and ***sense of concern*** for water resource problems and consequences are needed for collective action (Schwartz 1977, Stern & Dietz 1994).
- ***Mutual responsibility***, also referred to as civic responsibility (Parisi et al. 2004), is the recognition of being accountable for one's actions and having a common duty to address a water resource problem or need (Schwartz 1977).
- ***Collective action*** (and public-sphere action) includes conservation citizenship (e.g., attending a watershed planning meeting or being willing to pay a fee for water resource protection), conservation advocacy (e.g., participating in a volunteer event or joining a watershed organization, Stern 2000), and community organizing (Holley 2012).

Visual Depiction

Visual depictions of SM2 will vary depending on the monitoring tool and the type of data (i.e., quantitative, qualitative, spatial) gathered. Quantitative data output may be displayed as descriptive statistics, frequency tables, and graphics (e.g., bar/pie charts, spatial analysis maps). Qualitative data output may consist of direct quotes, theme tables, and graphics (e.g., concept maps, decision frameworks). Example data outputs are provided below (Figures 2-3, Tables 1-3).

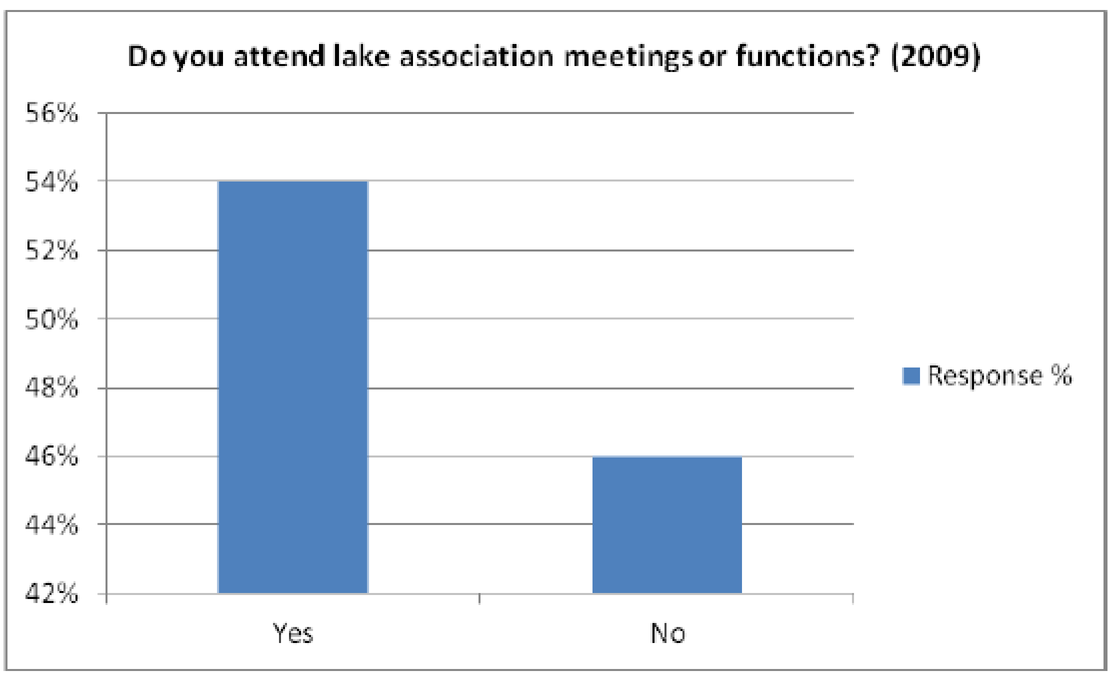

Figure 2. Percentage of Itasca County respondents who reported attending lake association meetings (Eckman & Blickenderfer 2012)

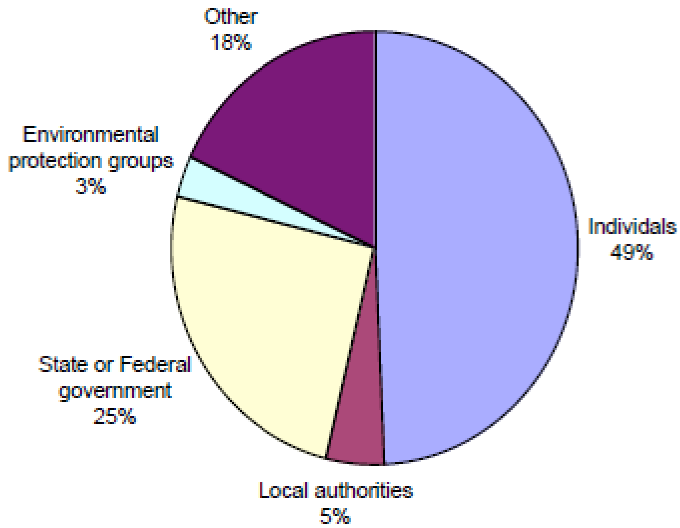

Figure 3. Percentage of Longfellow/Seward respondents identifying each category as ultimately responsible for the environment (Nerbonne & Schreiber 2005)

Table 1. Vermillion River Watershed respondent community identity (Davenport & Pradhananga 2012)

When I think of my community I think of...	N	Mean[a]	SD	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Don't know/Not sure
The city or township in which I live	311	1.49	0.76	1.0	1.3	6.4	30.0	60.7	0.6
My nearest neighbors	306	1.08	1.13	5.5	5.5	9.6	32.8	45.0	1.6
People who live within 1-3 miles	306	0.99	1.02	3.2	5.8	14.8	39.7	35.2	1.3
The county in which I live	309	0.67	1.03	3.2	11.3	21.5	42.8	20.6	0.6
The watershed in which I live	300	0.12	1.24	13.8	11.6	36.3	19.0	15.8	3.5
The entire state of MN	308	0.04	1.30	17.4	15.1	28.3	23.2	15.1	1.0

Source: Question 1; Vermillion River watershed survey

[a]Responses based on a five-point scale from strongly disagree (-2) to strongly agree (+2)

Table 2. Statistical differences between streamside buffer adopters and non-adopters in civic behaviors among Vermillion River and Sand Creek Watershed respondents (Davenport & Pradhananga 2012)

In the past 12 months, have you...[a]		Yes (%)	Chi-square[b] (χ^2)	Phi[c]
Attended a meeting, public hearing or community discussion group about an environmental issue?	Buffers	91	11.626	0.17
	No Buffers	9		
Discussed water quality issues with community members?	Buffers	85	11.528	0.17
	No Buffers	15		
Read any newsletters, magazines or other publication written by environmental groups?	Buffers	83	27.998	0.26
	No Buffers	17		

[a]Response options were yes or no.
[b]Chi-square statistic for testing the significance of differences across groups or variables. Only items with statistical differences at a significance level of p≤.001 (0.1% chance the difference is because of random variability) reported here.
[c]Statistic for measuring the strength of the relationship between variables.

Table 3. Minnehaha Creek Watershed study participant reported relational constraint to community engagement in water resource protection and restoration (Pradhananga & Davenport 2013)

Category	Theme *Descriptors*	FD*	ANMCM	AMCM
Shared beliefs	**Polarized society** *Little societal agreement exists about solutions to water resource problems*	x		
	Lack of agreement on issues *Disagreements about threats to the community*		x	
Sense of community	**Lack sense of neighborhood identity** *Lack of sense of identity in neighborhoods constrains engagement in those neighborhoods*	x		
Intercultural relationships	**Strained intercultural relationships** *Lack of understanding and trust between racial/ethnic community members*			x

*Participant stakeholder group affiliation (FD: formal decision makers, ANMCM: active non-minority community members, AMCM: active minority community members); an “x” indicates at least one participant in the stakeholder group identified the theme.

Target

The overarching goal for water resource projects is to enhance community capacity to engage in water resource protection and restoration. For SM2 the goal is to enhance relational capacity to engage in water resource protection and restoration. More specifically, SM2 targets should include

- Facilitating social networks for knowledge and information exchange
- Promoting social connectedness, trust and shared identity
- Ensuring that diversity is valued in water resource planning and programming

- Encouraging positive social interactions and managing conflict effectively
- Increasing common awareness and concern about water resource problems in a community
- Developing a mutual sense of responsibility for water resource problems, consequences, and solutions
- Inspiring collective action associated with water resource protection and restoration

There is no specific quantitative target for this measure. In the social measures monitoring system, project-specific outcomes indicators, outputs (i.e., products and services), performance standards (i.e., minimally acceptable conditions), and targets will be determined and coordinated by program staff and local project teams. For monitoring continuity and consistency of SM2, indicators, outputs, standards and targets should be based on SM2 and its eight core indicators. Identifying and incorporating local stakeholders' criteria for success into water resource planning is critical to building community commitment for clean water projects (Davenport et al. 2010). In certain areas, stakeholders may be asked to identify indicators, outputs, performance standards and targets. Using participatory research and civic engagement methods, stakeholders can be encouraged to establish meaningful measures of success as they work toward water resource goals.

Baseline

The baseline will vary depending on indicator, watershed and community of focus.

Geographical Coverage

The social measures monitoring system may be applied at multiple scales using statewide, regional, watershed- or community-specific assessments. The monitoring tools also are effective at multiple scales, assuming sample size needs are considered. Agencies, programs and projects are working at multiple scales and thus the measures and tools must be readily scaled up and down.

Monitoring can also be scaled according to Priority Management Zones/Areas (PMZ/PMA), sentinel watersheds where interagency resources for complementary social data may be greatest, or subwatersheds where civic engagement strategies require a phased approach to PMZ/PMAs.

Data and Methodology

Methodology for Measure Calculation

A range of assessments will be conducted in specific subwatersheds and with specific communities that have experienced water resource problems or are particularly vulnerable to water resource problems. Assessments also will be conducted in priority areas for water resource protection.

SM2 monitoring will be conducted using any one or combination of standard social science assessment tools (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7).

Data Source

To date, no centralized database exists for social measures monitoring. Currently data are available in published project reports and unpublished records of Clean Water Legacy Act (CWLA) watershed projects underway.

Data Collection Period

Data collection periods will vary by project based on project scope and purpose, monitoring objectives and resource availability.

Data Collection Methodology and Frequency

Each project will specify data collection method (i.e., assessment tool) and frequency based on project scope and purpose, monitoring objectives and resources available. Social measures assessments can be conducted at any time in a project for baseline understanding to inform design of civic engagement processes, outreach, education and other capacity-building activities; for engaging diverse stakeholders, checking in on progress and preliminary outcomes, and sharing knowledge; and for project outcomes monitoring, evaluation and adaptation. The data collection methodology (i.e., assessment tool selection) also will depend on the social measures, core indicators and project-specific indicators selected for monitoring (see Social Measures Monitoring System Overview: Appendix A). Project managers should carefully consider the type of information generated, strengths and limitations of each tool (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7) when choosing assessment tools.

Supporting Data Set

To date, no centralized database exists for SM2. Currently social data are available in published project reports and unpublished CWLA project records.

Future Improvements

The social measures monitoring system tiered approach (see Social Measures Monitoring System Overview: Figure 7) demonstrates that monitoring will evolve and intensify as capacities are built within agencies, programs and projects.

Building skills and understanding will require initial investment in technical assistance and training from social measures and social assessment experts. Early investments should include convening experts and practitioners in social science to conduct assessments independently or to partner with project teams to conduct cooperative assessments. Concurrently, investments should be made in convening experts and practitioners in training opportunities. Formalizing existing informal training forums and peer learning networks within and across agencies will facilitate knowledge, skill, and leadership development in social measures monitoring. Training staff is critical to the success of the social measures monitoring system. Each agency may have a unique approach to implementing and tracking the social measures. The strength of the framework is that it is systematic and flexible.

Financial Considerations

Developing and administering social measures monitoring methodologies which track changes over time in individual capacity and behaviors to protect and restore water resources will require additional financial investments from state and local government entities. Examples of investments may include

1) Development and honing of social science data collection and analysis methodologies to allow for gathering of credible and useful information for watershed managers and others addressing the social dimension of watershed projects.

2) Building knowledge and competency in social science monitoring and program evaluation within state and local government agency staff.

3) Consultation with professionals that can provide expertise to support this effort in areas such as of social science monitoring and program evaluation.

4) Creation of databases necessary to manage the data that are collected from projects across the state.

Social science data collection and program evaluation are evolving areas of practice within the field of watershed management. Investments in this work are likely to begin slowly and increase as the need for information and trend analysis data is recognized. It is advisable to take a phased approach to rolling out any new monitoring or program evaluation systems to support grounded and informed decisions that will support long-term institutional and program capacity building in this arena.

Measure Points of Contact

Agency/Affiliation Information

Social Measures Team Members
Margaret Wagner (Chair)
Minnesota Department of Agriculture
Margaret.wagner@state.mn.us
651-201-6488

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

Tannie Eshenaur
Minnesota Department of Health
tannie.eshenaur@state.mn.us

Katherine Logan
Minnesota Pollution Control Agency
katherine.logan@state.mn.us

Barb Radke
Board of Soil and Water Resources
barbara.radke@state.mn.us

Sharon Pfeifer
Minnesota Department of Natural Resources
sharon.pfeifer@state.mn.us

Preparer

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

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Social Measure 3: Change over time in organizational capacity to engage in water resource protection and restoration[1]

Measure Background

Social measure (SM) 3, *change over time in organizational capacity to engage in water resource protection and restoration*, has four overarching goals. SM3 is designed to enable project managers to (1) assess and track over time a community's organizational capacity to engage in water resource protection and restoration and (2) evaluate effects of water resource outreach, education and civic engagement programs on organizational capacity. Monitoring organizational capacity also will help water resource project managers and community leaders (3) identify and address constraints to organizational capacity and (4) maintain and build organizational capacity. Organizational capacity is a body of community resources created by government and non-government organizations that operate within a community. A community's **organizational capacity encompasses member diversity, leadership, mission, learning, community engagement, collaborative decision making processes, and conflict management. Activities that support organizational development are critical to water resource protection and restoration. Organizations enhance the ability of a community to respond to problems and to engage in long-term initiatives.** SM3 has 11 core indicators (Figure 1) and can include multiple project-specific indicators (see Social Measures Monitoring System Overview: Appendix A for Project-Specific Indicator Sample Sets).

Core Indicators of Organizational Capacity

1. **Member diversity**
2. Effective **leadership** and leadership development
3. Access to **information**, feedback **monitoring**, **learning** and **knowledge** dissemination
4. Clear organizational **identity** and **mission**
5. Appropriate **authority and legal options needed to implement** water resource programs
6. Meaningful **community engagement**
7. **Collaborative decision making** processes
8. **Conflict management**
9. **Accountability** for water resource problems, consequences and solutions
10. Positive **influence** on the community in water resource protection and restoration
11. Effective **engagement** in water resource protection and restoration

Figure 1. SM3 core indicators

In the last decade an increasing amount of social data has been gathered to inform water resource management in Minnesota. However, past assessments have been predominantly site-specific or project specific case studies and most have used survey tools. Many past data collection efforts have

[1] Please refer to the Social Measures Monitoring System Overview document for general information about the five social measures and a definition of terms and concepts used in individual metadata sheets.

lacked science-based or standardized measures to enable meaningful comparison or aggregation. Furthermore, there has been no systematic effort to compile or synthesize this information to date.

A few recent Minnesota assessment projects have relevance to organizational capacity for water resource protection and restoration. For example, Pradhananga and Davenport (2013) examined organizational capacities and constraints associated with community engagement in water resource protection and restoration from the perspectives of diverse stakeholders in the Minnehaha Creek Watershed's urban corridor. Several studies have explored organizational influence on individual community members including where respondents get information about water resources or conservation practices (Davenport & Olson 2012, Eckman & Henry 2012), respondents' most trusted sources of information (Albright & Eckman 2012, Eckman & Consoer 2012) and the extent to which organizations influence respondents' conservation decision making (Davenport & Olson 2012, Davenport & Pradhananga 2012, Nerbonne & Schreiber 2005).

Measure Description

SM3 *change over time in organizational capacity to engage in water resource protection and restoration* is grounded in social science theory in the fields of psychology, sociology, community development and public health (Chaskin et al. 2001, Foster-Fishman et al. 2001, Goodman et al. 1998); empirical research conducted in Minnesota and across the U.S.; and ongoing dialogue with water resource professionals and policy-makers. The Multilevel Community Capacity Model (MCCM) for sustainable watershed management (Davenport & Seekamp 2013, Figure 1) provides a broad framework for monitoring and evaluating relational capacity to engage in water resource protection and restoration**.** This measure provides data to identify where to focus community capacity-building or where to target communication, education outreach and civic engagement programs. In this model "organizational capacity" has multiple indicators including strong leadership, fair and meaningful member engagement, member diversity, knowledge networks, collaborative decision making and conflict management.

The 11 core indicators of SM3 (Figure 1) draw upon several social science constructs described below.

- ***Member diversity*** in any organization or collaborative group is important. Member diversity (e.g., community role, interest, and sociodemographic group diversity) enhances creativity and resource pooling in problem-solving and increases representation of diverse stakeholders in decisions (Bidwell & Ryan 2006, Floress et al. 2009).
- ***Leadership*** is a second indicator of organizational capacity (Berkes & Ross 2013, Floress et al. 2009, Kenney 1999) and a rich body of literature expounds upon various qualities of leadership and how leaders are developed. Leadership is viewed as a central factor in community resilience (Berkes & Ross 2013) and community ability to effect change (Morton & Padgitt 2005).
- Organizations that have *access to* ***information****, engage in* ***monitoring feedback****,* ***learn*** and ***disseminate knowledge*** tend to be high capacity organizations and have the potential to positively influence the community in water resource management. Researchers emphasize the role of organizations as central hubs in communities for information about resources, problems, and action. Organizations help communities co-create, synthesize and disseminate knowledge (Berkes & Ross 2013) that can increase awareness of water resource problems and consequences, enhance personal and civic sense of responsibility and increase perceived behavioral control. Organizations also play a key role in natural

resource management by integrating different forms of knowledge including western scientific, technical, civic and traditional or indigenous knowledge (Berkes & Ross 2013, Morton 2008, McGuire et al. 2013).

- Organizations need to have a ***clear identity* and *mission*** (Floress et al. 2009, Environmental Ground Inc. n.d.) to be effective. In the context of water resources, higher capacity communities will have multiple organizations whose identity and mission at least indirectly relate to community engagement in water resource protection and restoration.
- ***Community member engagement*** (Rickenbach & Reed 2002, Morton 2008), ***collaborative decision making*** (Morton 2008, Rickenbach & Reed 2002, Wondolleck & Yaffee 2000), and ***conflict management*** (Morton 2008, Rickenbach & Reed 2002) are central functions of high capacity organizations and collaborative groups. Government and non-government organizations who are effective at these activities can help facilitate broad community engagement in water resource protection and restoration.
- Organizations and collaborative groups should be appropriately ***accountable*** for water resource protection and restoration. Civic responsibility (Parisi et al. 2004) in water resource management is not solely placed on citizens but also on organizations. Organizations may have information or expertise that is important to water resource protection and restoration, they may have authority in decision making or power to block decisions, or they may be a resource for facilitating communication, outreach or community engagement programs. Organizations can also have a direct impact on water resources in their land/resource uses or other conservation actions.
- An organization's ***influence on the community*** and own effective ***engagement*** in water resource protection and restoration are important higher order indicators in SM3. The extent to which community members, stakeholders, and other organizations see an organization as successful and influential is a significant component of a community's organizational capacity.

Visual Depiction

Visual depictions of SM3 will vary depending on the monitoring tool and the type of data (i.e., quantitative, qualitative, spatial) gathered. Quantitative data output may be displayed as descriptive statistics, frequency tables, and graphics (e.g., bar/pie charts, spatial analysis maps). Qualitative data output may consist of direct quotes, theme tables, and graphics (e.g., concept maps, decision frameworks). Example data outputs are provided below (Figures 2-6, Tables 1-2).

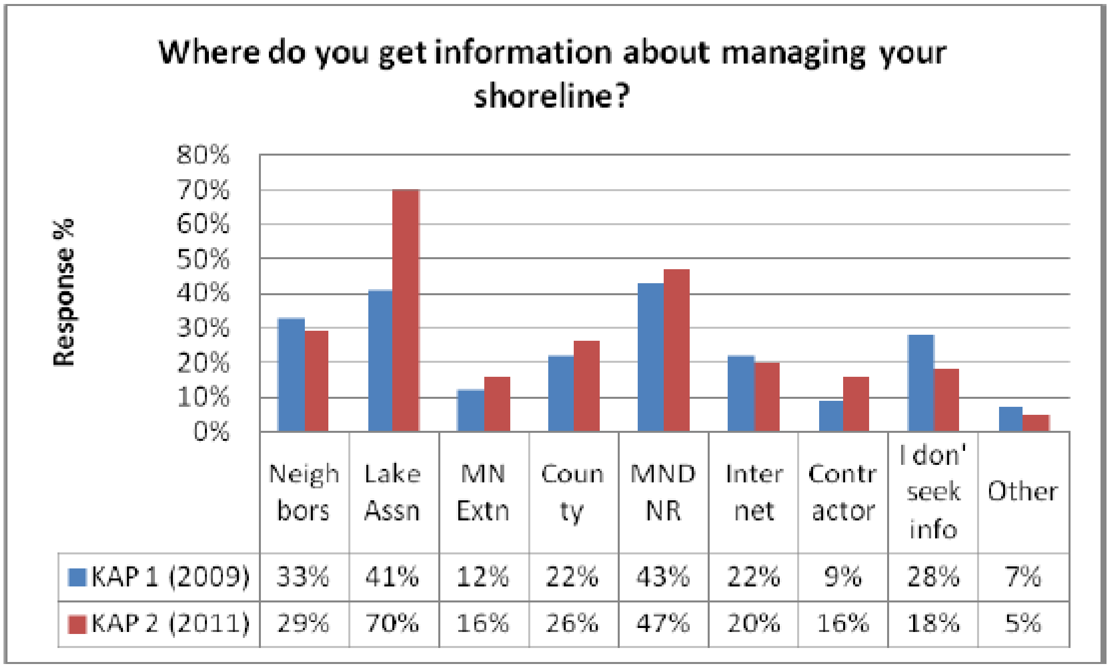

Figure 2. East Ottertail County respondent preferences for obtaining shoreland information (Eckman & Henry 2012)

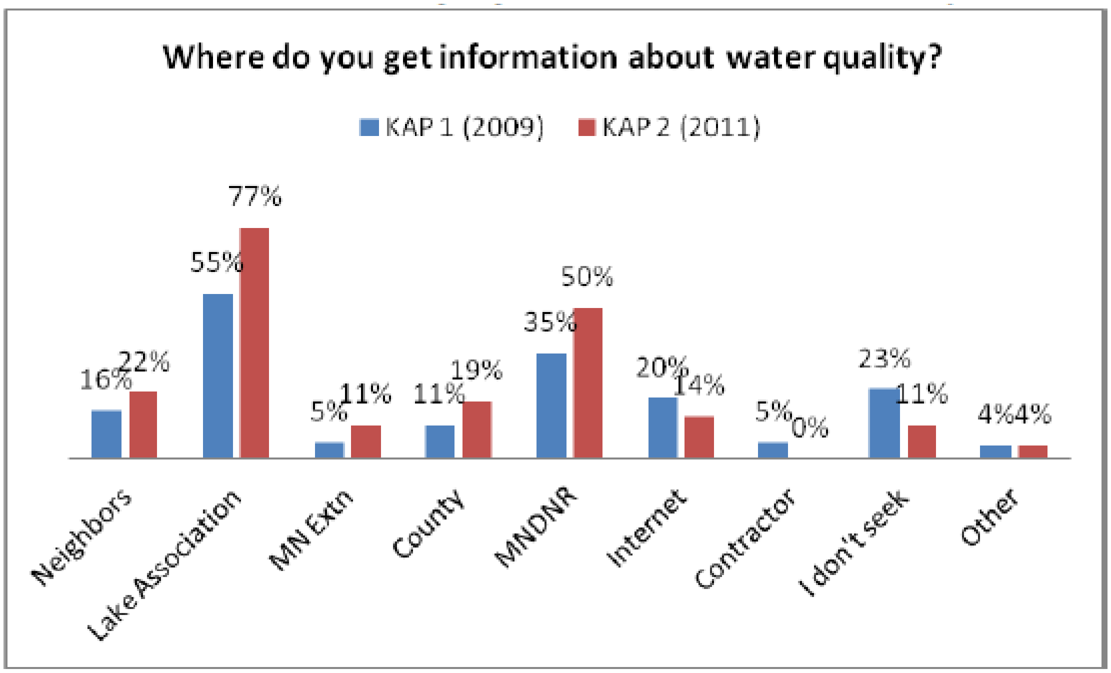

Figure 3. East Ottertail County respondent reported sources of information about water quality (Eckman & Henry 2012)

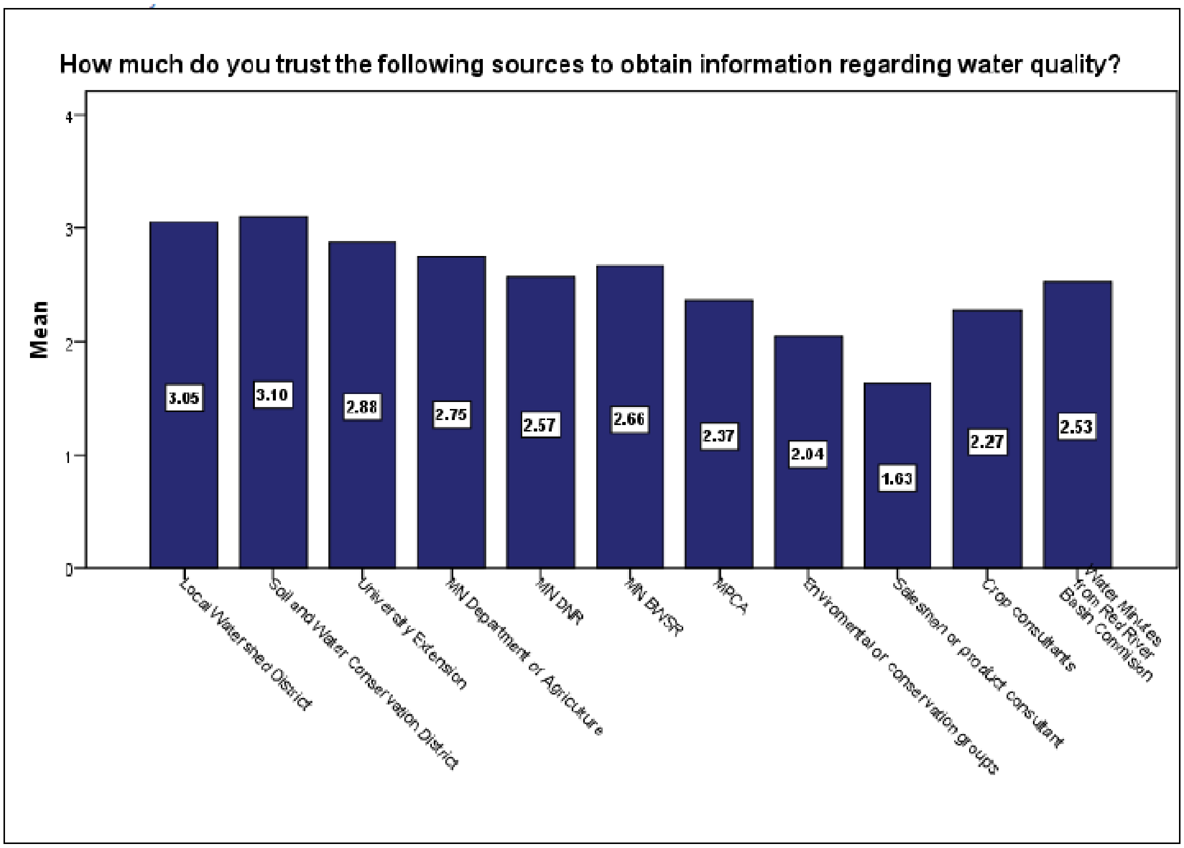

Figure 4. Buffalo Red River Watershed respondent trust in sources of information about water quality (on a 4-pt. scale from 1 (not at all) to 4 (very much), Albright & Eckman 2012).

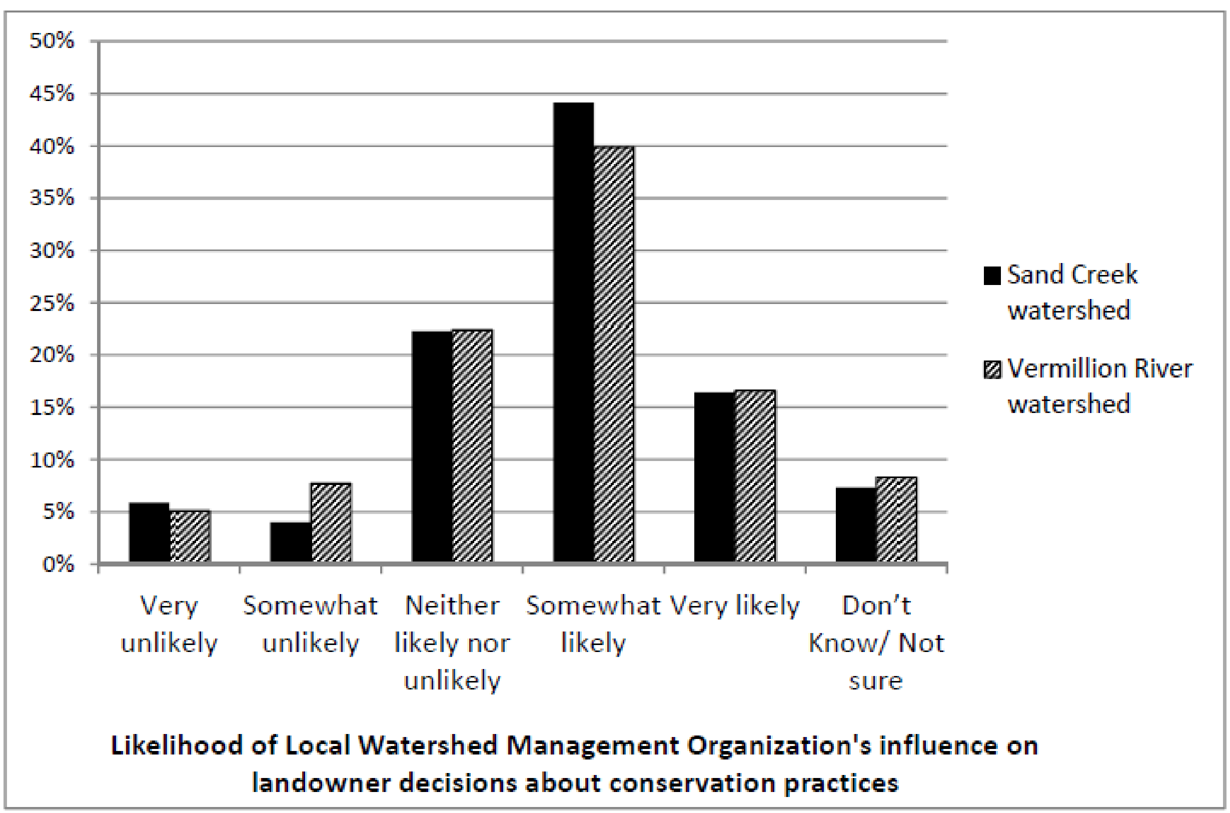

Figure 5. Vermillion River and Sand Creek Watershed respondent reported likelihood of influence of local watershed management organization on their conservation practice decisions (Davenport & Pradhananga 2012)

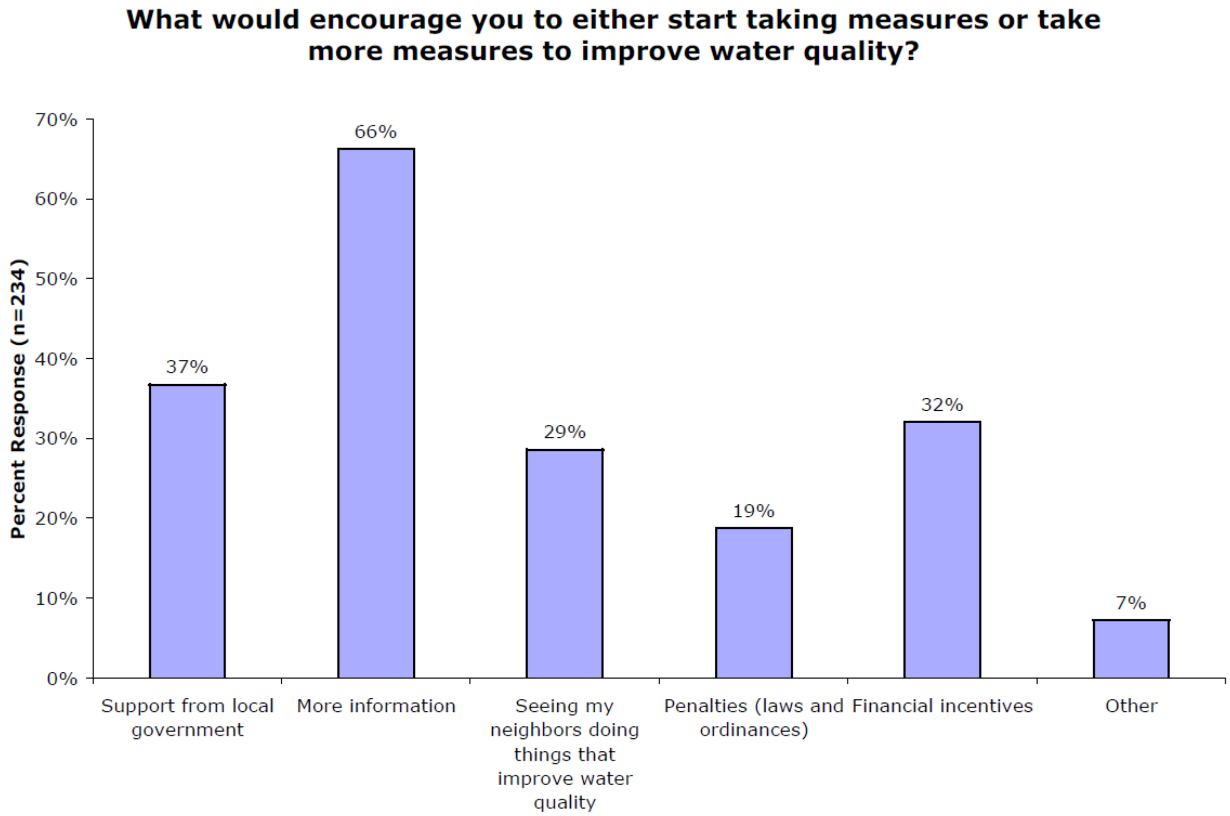

Figure 6. Percentage of Greater Longfellow and Seward respondents who believe the conditions would influence their conservation decision making (Nerbonne & Schreiber 2005).

Table 1. Sand Creek Watershed respondent reported likelihood of influence of individuals and organizations on their conservation practice decisions (Davenport & Pradhananga 2012)

	N	Mean[a]	SD	Very unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Very likely	Don't know/Not sure
My family	426	1.00	0.96	3.5	2.6	16.0	43.9	32.2	1.9
My county's Soil and Water Conservation District	426	0.86	1.02	4.9	4.0	15.5	46.7	24.4	4.5
MN DNR	427	0.73	1.12	7.3	4.9	18.5	41.5	24.1	3.7
My local Water Management Organization	426	0.66	1.02	5.9	4.0	22.3	44.1	16.4	7.3
My neighbors	426	0.57	0.96	5.2	7.0	23.0	52.1	10.8	1.9
MPCA	427	0.53	1.21	10.3	5.9	21.3	36.8	19.7	6.1
People in my community	426	0.50	0.90	4.0	8.0	27.0	50.7	6.8	3.5
My local government	425	0.44	1.08	8.0	8.0	24.9	43.3	11.3	4.5
Sportspersons club	425	0.30	1.19	10.4	12.7	26.1	32.9	14.6	3.3
Environmental organizations	426	0.29	1.21	11.3	12.7	22.3	36.6	13.1	4.0
My county's Farm Bureau	427	0.12	1.08	10.3	9.4	35.1	27.6	6.3	11.2
Property rights organizations	428	0.01	1.12	12.1	15.2	32.7	27.1	6.5	6.3

Source: Question 8; Sand Creek watershed survey

[a]Responses based on a five-point scale from very unlikely (-2) to very likely (+2).

Table 2. Minnehaha Creek Watershed study participant reported community organizational capacity for engagement in water resource protection and restoration (Pradhananga & Davenport 2013)

Category	Theme *Descriptors*	FD*	ANMCM	AMCM
Leadership	**Leadership** *Leadership of the city government and various organizations*		x	
Responsiveness	**Responsive government** *City government tries to engage the community; city is effective at responding to problems; city responds to community problems; city helps with grants*	x	x	x
	Community proactive in addressing issues *There are many resident initiated projects in the community*		x	
	Adaptability *Community is willing to adapt to changing conditions such as funding cuts*		x	
	Community influence on city council *Community has an influence on city council; city council is concerned about the well-being of the community*	x	x	
	Ability to creatively respond to challenges *Community has the ability to be creative and is willing to take risks*	x		
Exemplary organizations	**Exemplary organizations** *Presence of organizations such as MCWD, Blake Road Corridor Collaborative, Rotary club and other community organizations*	x	x	
Partnerships	**Partnerships between organizations** *City and community organizations partnerships to address community issues; partnerships among various organizations for water resource restoration projects*	x	x	
	Partnership development *Organizations willing to seek partnerships and make compromises to make the partnerships work*	x		
	Member networks *Community members connected through formal networks such as organizations and associations*	x		

*Participant stakeholder group affiliation (FD: formal decision makers, ANMCM: active non-minority community members, AMCM: active minority community members); an "x" indicates at least one participant in the stakeholder group identified the theme.

Target

The overarching goal for water resource projects is to enhance community capacity to engage in water resource protection and restoration. For SM3 the goal is to enhance organizational capacity to engage in water resource protection and restoration. More specifically, SM3 targets should include

- Increasing member diversity in water resource-related organizations or collaborative groups
- Developing effective leaders in water resource protection and restoration organizations
- Improving organizations' access to information, increasing their feedback monitoring, and enhancing their learning and knowledge dissemination
- Establishing water resource-related organizations' identity and mission in a community
- Increasing opportunities for meaningful community engagement in organizations
- Supporting and improving collaboration in water resources decision making processes
- Increasing effectiveness in conflict management
- Building organizational accountability for water resource problems, consequences and solutions.
- Enhancing an organization's positive influence on the community in water resource protection and restoration
- Facilitating effective organization engagement in water resource protection and restoration

There is no specific quantitative target for this measure. In the social measures monitoring system, project-specific outcomes indicators, outputs (i.e., products and services), performance standards (i.e., minimally acceptable conditions), and targets will be determined and coordinated by program staff and local project teams. For monitoring continuity and consistency of SM3, indicators, outputs, standards and targets should be based on SM3 and its 11 core indicators. Identifying and incorporating local stakeholders' criteria for success into water resource planning is critical to building community commitment for clean water projects (Davenport et al. 2010). In certain areas, stakeholders may be asked to identify indicators, outputs, performance standards and targets. Using participatory research and civic engagement methods, stakeholders can be encouraged to establish meaningful measures of success as they work toward water resource goals.

Baseline

The baseline will vary depending on indicator, watershed and community of focus.

Geographical Coverage

The social measures monitoring system may be applied at multiple scales using statewide, regional, watershed- or community-specific assessments. The monitoring tools also are effective at multiple scales, assuming sample size needs are considered. Agencies, programs and projects are working at multiple scales and thus the measures and tools must be readily scaled up and down.

Monitoring can also be scaled according to Priority Management Zones/Areas (PMZ/PMA), sentinel watersheds where interagency resources for complementary social data may be greatest, or subwatersheds where civic engagement strategies require a phased approach to PMZ/PMAs.

Data and Methodology

Methodology for Measure Calculation

A range of assessments will be conducted in specific subwatersheds and with specific communities that have experienced water resource problems or are particularly vulnerable to water resource problems. Assessments also will be conducted in priority areas for water resource protection.

SM3 monitoring will be conducted using any one or combination of standard social science assessment tools (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7).

Data Source

To date, no centralized database exists for social measures monitoring. Currently data are available in published project reports and unpublished records of Clean Water Legacy Act (CWLA) watershed projects underway.

Data Collection Period

Data collection periods will vary by project based on project scope and purpose, monitoring objectives and resource availability.

Data Collection Methodology and Frequency

Each project will specify data collection method (i.e., assessment and monitoring tool) and frequency based on project scope and purpose, monitoring objectives and resources available. Monitoring objectives should take into consideration (1) the community of focus in water resource protection and restoration and (2) the organizational capacities that are significant to stakeholder engagement in water resource protection and restoration. The data collection methodology (i.e., assessment tool selection) also will depend on the core constructs and project-specific indicators selected for monitoring (Appendix A). Project managers should carefully consider the type of information generated, strengths and limitations of each tool (see Social Measures Overview: Tables 1, 2 and Figure 6) when choosing assessment tools.

Supporting Data Set

To date, no centralized database exists for SM3. Currently social data are available in published project reports and unpublished records of CWLA watershed projects.

Future Improvements

The social measures monitoring system tiered approach (see Social Measures Monitoring System Overview: Figure 7) demonstrates that monitoring will evolve and intensify as capacities are built within agencies, programs and projects.

Building skills and understanding will require initial investment in technical assistance and training from social measures and social assessment experts. Early investments should include convening experts and practitioners in social science to conduct assessments independently or to partner with project teams to conduct cooperative assessments. Concurrently, investments should be made in convening experts and practitioners in training opportunities. Formalizing existing informal training forums and peer learning networks within and across agencies will facilitate knowledge, skill, and leadership development in social measures monitoring. Training staff is critical to the success of the social measures monitoring system. Each agency may have a unique approach to implementing and tracking the social measures. The strength of the framework is that it is systematic and flexible.

Financial Considerations

Developing and administering social measures monitoring methodologies which track changes over time in individual capacity and behaviors to protect and restore water resources will require additional financial investments from state and local government entities. Examples of investments may include

1) Development and honing of social science data collection and analysis methodologies to allow for gathering of credible and useful information for watershed managers and others addressing the social dimension of watershed projects.

2) Building knowledge and competency in social science monitoring and program evaluation within state and local government agency staff.

3) Consultation with professionals that can provide expertise to support this effort in areas such as of social science monitoring and program evaluation.

4) Creation of databases necessary to manage the data that are collected from projects across the state.

Social science data collection and program evaluation are evolving areas of practice within the field of watershed management. Investments in this work are likely to begin slowly and increase as the need for information and trend analysis data is recognized. It is advisable to take a phased approach to rolling out any new monitoring or program evaluation systems to support grounded and informed decisions that will support long-term institutional and program capacity building in this arena.

Measure Points of Contact

Agency/Affiliation Information

Social Measures Team Members
Margaret Wagner (Chair)
Minnesota Department of Agriculture
Margaret.wagner@state.mn.us
651-201-6488

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

Tannie Eshenaur
Minnesota Department of Health
tannie.eshenaur@state.mn.us

tannie.eshenaur@state.mn.us

Katherine Logan
Minnesota Pollution Control Agency
katherine.logan@state.mn.us

Barb Radke
Board of Soil and Water Resources
barbara.radke@state.mn.us

Sharon Pfeifer
Minnesota Department of Natural Resources
sharon.pfeifer@state.mn.us

Preparer

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

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Social Measure 4: Change over time in programmatic capacity to engage in water resource protection and restoration[1]

Measure Background

Social measure (SM) 4, *change over time in programmatic capacity to engage in water resource protection and restoration*, has four overarching goals. SM4 is designed to enable project managers to (1) assess and track over time a community's programmatic capacity to engage in water resource protection and restoration and (2) evaluate effects of water resource outreach, education and civic engagement programs on programmatic capacity. Monitoring programmatic capacity also will help water resource project managers and community leaders (3) identify and address constraints to programmatic capacity and (4) maintain and build programmatic capacity. Programmatic capacity is a set of community resources created by government and non-government organizations and groups that operate within a community. **Programmatic capacity refers to a community's ability to implement programs with clear goals and adequate resources to be effective. In addition, programs are based on the best available knowledge, coordinated across boundaries, and monitored and evaluated. Finally programs in high capacity communities engage citizens, further build community capacity and protect and restore water resources**. SM4 has nine core indicators (Figure 1) and can include multiple project-specific indicators (see Social Measures Monitoring System Overview: Appendix A for Project-Specific Indicator Sample Sets).

Core Indicators of Programmatic Capacity

1. Programs have **clear goals and objectives**
2. **Adequate physical, financial, and technical resources** are available for program support
3. **Adequate human resources** are available for program support
4. Programs are based on the **best available scientific, traditional, and civic knowledge**
5. Programs are effective in **engaging citizens**
6. Program planning and implementation is **coordinated across agencies and jurisdictional boundaries**
7. Program **ecological, social and economic outcomes are monitored and evaluated for adaptation**
8. Programs **build community capacity** to engage in water resource protection and restoration
9. Programs are **effective in water resource protection and restoration**

Figure 1. SM4 core indicators

In the last decade an increasing amount of social data has been gathered to inform water resource management in Minnesota. However, past assessments have been predominantly site-specific or project specific case studies and most have used survey tools. Many past data collection efforts have

[1] Please refer to the Social Measures Monitoring System Overview document for general information about the five social measures and a definition of terms and concepts used in individual metadata sheets.

lacked science-based or standardized measures to enable meaningful comparison or aggregation. Furthermore, there has been no systematic effort to compile or synthesize this information to date.

A few recent Minnesota assessment projects have relevance to programmatic capacity for water resource protection and restoration. Several studies have explored individual community member perceptions of programs including program likelihood of success (Davenport & Pradhananga 2012) and perceptions of the extent to which programs would maintain, increase, or constrain a pro-environmental behavior (Albright & Eckman 2012, Davenport & Pradhananga 2012, Lewandowski 2010). Other assessments have measured the direct effects of programs on indicators related to individual capacity such as stakeholder knowledge, beliefs, attitudes and behaviors. Program evaluation studies commonly measure these indicators before and after a program intervention to determine changes in individual capacity (Eckman & Blickenderfer 2012, Eckman & Consoer 2012, Eckman & Henry 2012, Eckman et al. 2011). A few qualitative studies have asked stakeholders in interviews or focus groups for recommendations on improving existing programs or the development of new programs (Davenport & Olson 2012, Pradhananga & Davenport 2013, Lewandowski 2010). For example, Pradhananga and Davenport (2013) identified strategies recommended by culturally diverse stakeholders for increasing community engagement in water resource protection and restoration in the Minnehaha Creek Watershed's urban corridor.

Measure Description

SM4 *change over time in programmatic capacity to engage in water resource protection and restoration* is grounded in social science theory in the fields of psychology, sociology, community development and public health (Chaskin et al. 2001, Foster-Fishman et al. 2001, Goodman et al. 1998); empirical research conducted in Minnesota and across the U.S.; and ongoing dialogue with water resource professionals and policy-makers. The Multilevel Community Capacity Model (MCCM) for sustainable watershed management (Davenport & Seekamp 2013, Figure 1) provides a broad framework for monitoring and evaluating relational capacity to engage in water resource protection and restoration**.** This measure provides data to identify where to focus community capacity-building or where to target communication, education outreach and civic engagement programs. In this model "programmatic capacity" has multiple indicators including transboundary coordination, collective action through resource pooling and innovation, integrated systems monitoring and program evaluation, and adaptive learning and flexibility.

The nine core indicators of SM4 (Figure 1) draw upon several social science constructs described below.

- Programs that have **clear goals and objectives** lead to better **transboundary coordination**, which promotes pooling of **physical, financial, technical and human resources** for implementation (Foster-Fishman et al. 2001, MacLellan-Wright et al. 2007). Clear goals and objectives also enable identification of actor and organization roles within programs (Brody et al. 2004, Kaplan et al. 2008).
- Programs also benefit from **multiple knowledge sources** (Fabricius et al. 2007) including scientific, traditional and civic knowledge.
- Programs should facilitate **community member engagement** (Rickenbach & Reed 2002, Morton 2008).

- **Social, economic and ecological monitoring, evaluation and adaptation** are critical to program success (Foster-Fishman et al. 2001, Brody et al. 2004, Armitage 2005, Folke et al. 2005, Allen 2006).
- The ultimate test of a program is that it **builds community capacity** and **protects and restores water resources**.

Visual Depiction

Visual depictions of SM4 will vary depending on the monitoring tool and the type of data (i.e., quantitative, qualitative, spatial) gathered. Quantitative data output may be displayed as descriptive statistics, frequency tables, and graphics (e.g., bar/pie charts, spatial analysis maps). Qualitative data output may consist of direct quotes, theme tables, and graphics (e.g., concept maps, decision frameworks). Example data outputs are provided below (Figures 2-6, Tables 1-2).

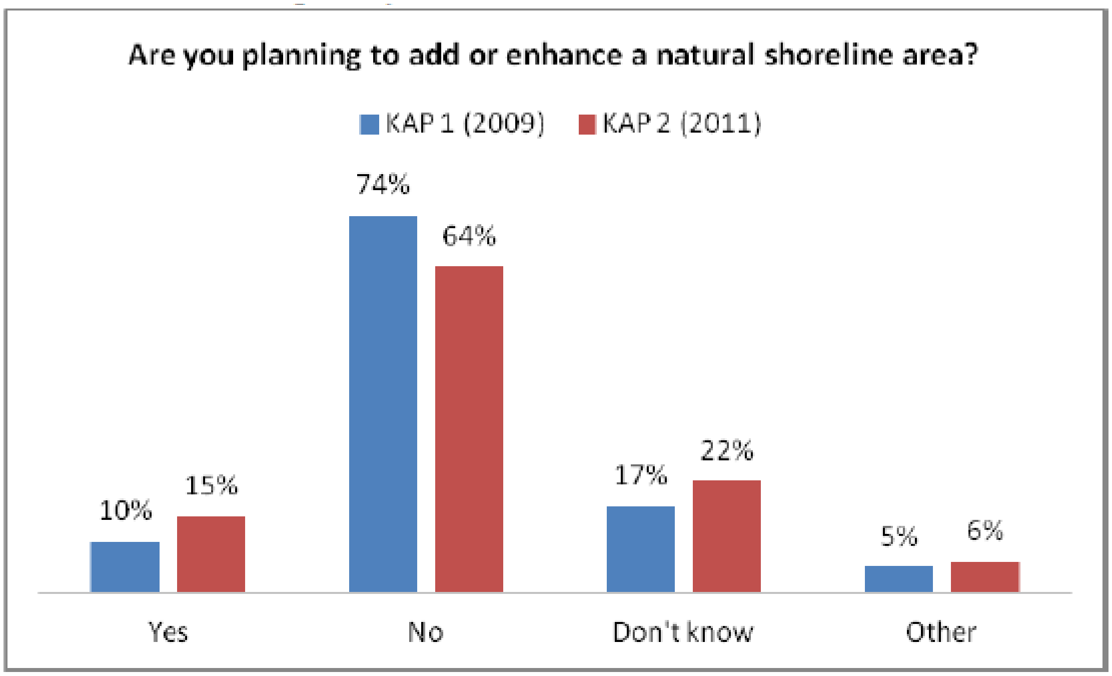

Figure 2. East Ottertail County respondent intention to add or enhance a natural shoreline before (KAP 1) and after program (KAP 2) interventions (Eckman & Henry 2012).

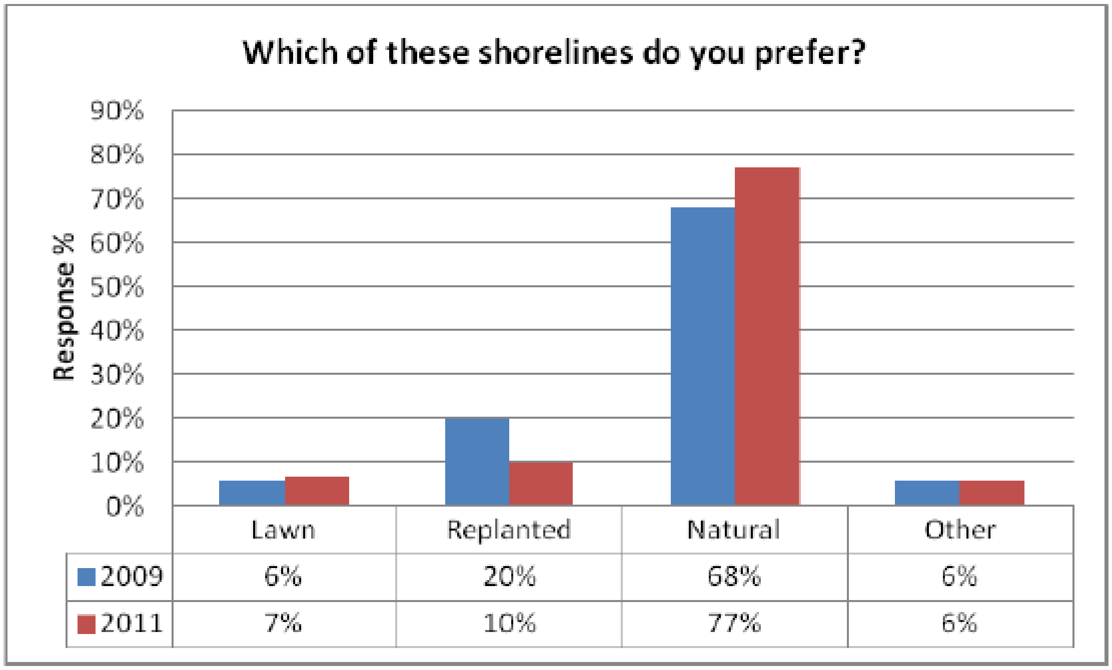

Figure 3. Itasca County resident shoreline preferences before (2009) and after (2011) program interventions (Eckman & Blickenderfer 2012).

Table 1. Vermillion River Watershed respondent beliefs about the likelihood that various management actions will protect water resources in Minnesota (Davenport & Pradhananga 2012)

	N	Mean[a]	SD	Very unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Very likely	Don't know/Not sure
Enforcing existing land use laws and regulations.	290	1.08	0.92	2.6	3.6	10.0	45.6	32.0	6.1
Conducting more water quality research and monitoring.	293	0.91	0.95	2.9	5.8	12.6	48.9	24.6	5.2
Coordinating land use and water planning efforts across communities.	290	0.88	0.93	2.6	4.6	17.6	46.4	23.5	5.2
Promoting voluntary adoption of conservation practices through increased education and outreach programs.	296	0.85	0.96	3.3	4.9	18.2	46.9	23.1	3.6
Engaging more citizens in local land use and water resource decision making.	288	0.81	0.93	2.6	4.6	22.1	43.3	21.2	6.2
Expanding incentive-based programs that offer payments to landowners for conservation practices	290	0.79	1.11	4.5	9.1	15.6	37.3	27.6	5.8
Increasing regulations that specifically address water resource management.	281	0.57	1.16	7.5	8.8	18.6	37.5	19.2	8.5

Source: Question 14; Vermillion River watershed survey
[a]Responses based on a five-point scale from very unlikely (-2) to very likely (+2).

Table 2. Minnehaha Creek Watershed study participant-identified strategies for enhancing programmatic capacity for engagement in water resource protection and restoration (Pradhananga & Davenport 2013)

Programmatic Capacity-Building Strategies and Tactics		FD*	ANMCM	AMCM
Tailor communication programs	**Employ social marketing tools** *Use tools such as social marketing to effectively communicate with diverse audiences*	x		
	Provide opportunities for public input *Allow stakeholders to voice their concerns*	x		
	Communicate successes *Demonstrate the positive impacts and social benefits of water resource protection*		x	
	Develop multi-media campaigns *Raise community member awareness of water resource issues through newsletters, websites, signage, petition, and electronic media*		x	x
	Use peer-to-peer networking *Support dialogue through one-to-one and small group meetings, word-of-mouth and by going door-to-door*		x	x
Tailor communication programs	**Address language barriers** *Address language barrier by employing people who speak same language as minority residents*			x
	Understand community concerns *Find out what most concerns the community*			x
	Host culturally relevant and family friendly events *Events should highlight culturally relevant entertainment and activities for children*			x
Establish and communicate goals	**Goal setting** *Set targets for environmental services; plan and redevelop to correct past mistakes; planning from experts to meet needs; set long-term, larger scale priorities across organizations*	x		x
	Communication of goals *Clearly communicate project goals*	x		
Set regulations and help residents and landowners comply	**Set environmental regulations** *Set regulations and codes to protect water resources*			x
	Provide information about compliance *Provide community members with information on how to comply with regulations*			x
	Enforcement Enforce regulations			x

*Participant stakeholder group affiliation (FD: formal decision makers, ANMCM: active non-minority community members, AMCM: active minority community members); an "x" indicates at least one participant in the stakeholder group identified the theme.

Target

The overarching goal for water resource projects is to enhance community capacity to engage in water resource protection and restoration. For SM4 the goal is to enhance programmatic capacity to engage in water resource protection and restoration. More specifically, SM4 targets should include

- Assisting with the development of clear goals and objectives
- Providing physical, financial and technical resource support
- Providing human resource support
- Compiling and synthesizing the best available scientific, technical and civic knowledge
- Facilitating civic engagement in programs
- Enhancing program coordination across agencies and jurisdictional boundaries
- Assisting with monitoring and evaluating ecological, social and economic outcomes and promoting adaptation
- Supporting programs in building community capacity
- Supporting programs in water resources protection and restoration

There is no specific quantitative target for this measure. In the social measures monitoring system, project-specific outcomes indicators, outputs (i.e., products and services), performance standards (i.e., minimally acceptable conditions), and targets will be determined and coordinated by program staff and local project teams. For monitoring continuity and consistency of SM4, indicators, outputs, standards and targets should be based on SM4 and its nine core indicators. Identifying and incorporating local stakeholders' criteria for success into water resource planning is critical to building community commitment for clean water projects (Davenport et al. 2010). In certain areas, stakeholders may be asked to identify indicators, outputs, performance standards and targets. Using participatory research and civic engagement methods, stakeholders can be encouraged to establish meaningful measures of success as they work toward water resource goals.

Baseline

The baseline will vary depending on indicator, watershed and community of focus.

Geographical Coverage

The social measures monitoring system may be applied at multiple scales using statewide, regional, watershed- or community-specific assessments. The monitoring tools also are effective at multiple scales, assuming sample size needs are considered. Agencies, programs and projects are working at multiple scales and thus the measures and tools must be readily scaled up and down.

Monitoring can also be scaled according to Priority Management Zones/Areas (PMZ/PMA), sentinel watersheds where interagency resources for complementary social data may be greatest, or subwatersheds where civic engagement strategies require a phased approach to PMZ/PMAs.

Data and Methodology

Methodology for Measure Calculation

A range of assessments will be conducted in specific subwatersheds and with specific communities that have experienced water resource problems or are particularly vulnerable to water resource problems. Assessments also will be conducted in priority areas for water resource protection.

SM4 monitoring will be conducted using any one or combination of standard social science assessment tools (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7).

Data Source

To date, no centralized database exists for social measures monitoring. Currently data are available in published project reports and unpublished records of Clean Water Legacy Act (CWLA) watershed projects underway.

Data Collection Period

Data collection periods will vary by project based on project scope and purpose, monitoring objectives and resource availability.

Data Collection Methodology and Frequency

Each project will specify data collection method (i.e., assessment tool) and frequency based on project scope and purpose, monitoring objectives and resources available. Social measures assessments can be conducted at any time in a project for baseline understanding to inform design of civic engagement processes, outreach, education and other capacity-building activities; for engaging diverse stakeholders, checking in on progress and preliminary outcomes, and sharing knowledge; and for project outcomes monitoring, evaluation and adaptation. The data collection methodology (i.e., assessment tool selection) also will depend on the social measures, core indicators and project-specific indicators selected for monitoring (see Social Measures Monitoring System Overview: Appendix A). Project managers should carefully consider the type of information generated, strengths and limitations of each tool (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7) when choosing assessment tools.

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Measure Points of Contact

Agency/Affiliation Information

Social Measures Team Members Margaret
Wagner (Chair)
Minnesota Department of Agriculture
Margaret.wagner@state.mn.us
651-201-6488

Mae Davenport
Department of Forest Resources University of
Minnesota
mdaven@umn.edu

Tannie Eshenaur
Minnesota Department of Health
tannie.eshenaur@state.mn.us

Katherine Logan
Minnesota Pollution Control Agency
katherine.logan@state.mn.us

Barb Radke
Board of Soil and Water Resources
barbara.radke@state.mn.us

Sharon Pfeifer
Minnesota Department of Natural Resources
sharon.pfeifer@state.mn.us

Preparer
Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

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Social Measure 5: Water resource management is perceived as fair and legitimate [1]

Measure Background

Social measure (SM) 5, *water resource management is perceived as fair and legitimate*, has four overarching goals. SM5 is designed to enable project managers to (1) assess and track over time the fairness and legitimacy of water resource management as perceived by stakeholders and to (2) evaluate effects of water resource outreach, education and civic engagement programs on perceived fairness and legitimacy. Monitoring perceived fairness and legitimacy also will help water resource project managers and community leaders (3) identify and address fairness and legitimacy concerns in water resource management and (4) maintain and build perceptions of legitimacy and fairness. **Perceived fairness in water** resource **management is maintained through just stakeholder interpersonal interactions, effective and inclusive stakeholder engagement processes, decisions that are consistent and absent of bias or favoritism, and the equitable distribution of management costs and benefits. Legitimacy is achieved when stakeholders perceive that managing organizations have valid authority and that decision making power is appropriately distributed among levels of government or management agencies.** SM5 has six core indicators (Figure 1) and can include multiple project-specific indicators (see Social Measures Monitoring System Overview: Appendix A for Project-Specific Indicator Sample Sets).

Core Indicators of Perceived Fairness and Legitimacy

1. Water resource planning and implementation **effectively engage stakeholders** and are inclusive of diverse populations
2. Water resource management organizations are perceived to have **valid authority to manage water resources**
3. Decision making power is perceived to be **appropriately distributed** among levels of government or management agencies most able to manage water resources effectively
4. Management decisions and programs are perceived as **consistent and absent of personal bias** or interest group favoritism
5. **Interpersonal interactions** among stakeholders around water resource issues are just
6. The **costs and benefits of water resource management** decisions and programs are equitably distributed

Figure 1. SM5 core indicators

In the last decade an increasing amount of social data has been gathered to inform water resource management in Minnesota. However, past assessments have been predominantly site-specific or project-specific case studies and most have used survey tools. Many past data collection efforts have lacked science-based or standardized measures to enable meaningful comparison or

[1] Please refer to the Social Measures Monitoring System Overview document for general information about the five social measures and a definition of terms and concepts used in individual metadata sheets.

aggregation. Furthermore, there has been no systematic effort to compile or synthesize this information to date.

A few recent Minnesota assessment projects have relevance to legitimacy and fairness in water resource protection and restoration. These have been primarily qualitative studies conducted through key informant interviews and focus groups (Davenport & Olson 2012, Pradhananga & Davenport 2013, Lewandowski 2010). For example, Davenport and Olson (2012) examined the perspectives of 30 farmers in Elm Creek and Rush River watersheds and learned that participants had concerns about the legitimacy of federal and state government in regulating agricultural practices. Similarly, Lewandowski (2010) conducted focus groups with farmers, drainage authorities and drainage engineers and concluded that perceived fairness of programs was a central principle associated with conservation drainage practices and design. Landowner participants emphasized the importance of predictability and consistency in regulatory programs and wetland delineation.

Measure Description

SM5, *water resource management is perceived as fair and legitimate*, is grounded in social and political science theory; empirical research conducted in Minnesota and across the U.S.; and ongoing dialogue with water resource professionals and policy-makers. Theories of environmental justice provide a strong foundation upon which to understand, assess and evaluate perceived fairness in water resource management. Contemporary models of environmental justice (see Smith & McDonough 2001, Wutich et al. 2013) include three concepts: (1) distributive justice or the equitable distribution of goods, services and burdens (i.e., fairness of outcomes); (2) procedural justice or fair access to information and representation in meaningful decision making processes (i.e., fairness in processes); and (3) interactional justice or fairness in stakeholder interactions, especially at inter-personal levels. Thus, fairness is demonstrated in deliberative *decision making processes* that are respectful and attentive to diverse stakeholders' views (Larson & Lach 2010, Lauber & Knuth 1999) and in *equitable distribution of a decision's costs and benefits* that does not disproportionately affect certain subpopulations (Smith & McDonough 2001). Interpersonal relationships between stakeholders may also influence perceived fairness in natural resource management (Lauber & Knuth 1999) and in particular, respectful and non-discriminatory interactions are important dimensions (Wutich et al. 2013). Bryant (1995 p. 6) links environmental justice to important elements of community capacity including individual, relational, and programmatic capacity:

> Environmental justice…refers to those cultural norms, values, rules, regulations, behaviors, policies, and decisions to support sustainable communities where people can interact with confidence that the environment is safe, nurturing, and productive. . . . These are communities where both cultural and biological diversity are respected and highly revered and where distributive justice prevails.

Perceived legitimacy also plays a critical role in water resource management and if lacking, can be a barrier to civic engagement (Jordan et al. 2011). Two conceptualizations of legitimacy are emphasized in the literature and are significant to water resource management: organizational legitimacy and decision legitimacy. Lockwood et al. (2010) define organizational legitimacy as "the validity of an organization's authority to govern that may be conferred by democratic statute, or earned through the acceptance by stakeholders of an organization's authority to govern" (p. 991).

Decision legitimacy is defined as power that is “devolved to the lowest level at which it can be effectively exercised” (p. 991).

Visual Depiction

Visual depictions of SM5 will vary depending on the monitoring tool and the type of data (i.e., quantitative, qualitative, spatial) gathered. Quantitative data output may be displayed as descriptive statistics, frequency tables, and graphics (e.g., bar/pie charts, spatial analysis maps). Qualitative data output may consist of direct quotes, theme tables, and graphics (e.g., concept maps, decision frameworks, word clouds).

Target

The overarching goal for water resource projects is to enhance community capacity to engage in water resource protection and restoration. For SM5 the goal is to enhance organization, decision, and program legitimacy and fairness in water resource protection and restoration. More specifically, SM5 targets should include

- Effectively engaging diverse stakeholders in water resource planning and implementation
- The equitable distribution of management costs and benefits; impacts are not disproportionate across diverse subpopulations within the community
- Demonstrating water resource management organizations’ authority is valid
- Demonstrating that decision making power is appropriately distributed among levels of government and management agencies most able to manage water resources effectively
- Facilitating and supporting fair and respectful interactions between stakeholders around water issues
- Making management decisions and designing/delivering programs that are consistent and absent of personal bias or interest group favoritism

There is no specific quantitative target for this measure. In the social measures monitoring system, project-specific outcomes indicators, outputs (i.e., products and services), performance standards (i.e., minimally acceptable conditions), and targets will be determined and coordinated by program staff and local project teams. For monitoring continuity and consistency of SM5, indicators, outputs, standards and targets should be based on SM5 and its six core indicators. Identifying and incorporating local stakeholders’ criteria for success into water resource planning is critical to building community commitment for clean water projects (Davenport et al. 2010). In certain areas, stakeholders may be asked to identify indicators, outputs, performance standards and targets. Using participatory research and civic engagement methods, stakeholders can be encouraged to establish meaningful measures of success as they work toward water resource goals.

Baseline

The baseline will vary depending on indicator, watershed and community of focus.

Geographical Coverage

The social measures monitoring system may be applied at multiple scales using statewide, regional, watershed- or community-specific assessments. The monitoring tools also are effective at multiple scales, assuming sample size needs are considered. Agencies, programs and projects are working at multiple scales and thus the measures and tools must be readily scaled up and down.

Monitoring can also be scaled according to Priority Management Zones/Areas (PMZ/PMA), sentinel watersheds where interagency resources for complementary social data may be greatest, or subwatersheds where civic engagement strategies require a phased approach to PMZ/PMAs.

Data and Methodology

Methodology for Measure Calculation

A range of assessments will be conducted in specific subwatersheds and with specific communities that have experienced water resource problems or are particularly vulnerable to water resource problems. Assessments also will be conducted in priority areas for water resource protection.

SM5 monitoring will be conducted using any one or combination of standard social science assessment tools (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7).

Data Source

To date, no centralized database exists for social measures monitoring. Currently data are available in published project reports and unpublished records of Clean Water Legacy Act (CWLA) watershed projects underway.

Data Collection Period

Data collection periods will vary by project based on project scope and purpose, monitoring objectives and resource availability.

Data Collection Methodology and Frequency

Each project will specify data collection method (i.e., assessment tool) and frequency based on project scope and purpose, monitoring objectives and resources available. Social measures assessments can be conducted at any time in a project for baseline understanding to inform design of civic engagement processes, outreach, education and other capacity-building activities; for engaging diverse stakeholders, checking in on progress and preliminary outcomes, and sharing knowledge; and for project outcomes monitoring, evaluation and adaptation. The data collection methodology (i.e., assessment tool selection) also will depend on the social measures, core indicators and project-specific indicators selected for monitoring (see Social Measures Monitoring System Overview: Appendix A). Project managers should carefully consider the type of information generated, strengths and limitations of each tool (see Social Measures Monitoring System Overview: Table 1, Figure 6 and 7) when choosing assessment tools.

Supporting Data Set

To date, no centralized database exists for SM5. Currently social data are available in published project reports and unpublished CWLA project records.

Future Improvements

The social measures monitoring system tiered approach (see Social Measures Monitoring System Overview: Figure 7) demonstrates that monitoring will evolve and intensify as capacities are built within agencies, programs and projects.

Building skills and understanding will require initial investment in technical assistance and training from social measures and social assessment experts. Early investments should include convening experts and practitioners in social science to conduct assessments independently or to partner with project teams to conduct cooperative assessments. Concurrently, investments should be made in convening experts and practitioners in training opportunities. Formalizing existing informal training forums and peer learning networks within and across agencies will facilitate knowledge, skill, and leadership development in social measures monitoring. Training staff is critical to the success of the social measures monitoring system. Each agency may have a unique approach to implementing and tracking the social measures. The strength of the framework is that it is systematic and flexible.

Financial Considerations

Developing and administering social measures monitoring methodologies which track changes over time in individual capacity and behaviors to protect and restore water resources will require additional financial investments from state and local government entities. Examples of investments may include

1) Development and honing of social science data collection and analysis methodologies to allow for gathering of credible and useful information for watershed managers and others addressing the social dimension of watershed projects.

2) Building knowledge and competency in social science monitoring and program evaluation within state and local government agency staff.

3) Consultation with professionals that can provide expertise to support this effort in areas such as of social science monitoring and program evaluation.

4) Creation of databases necessary to manage the data that are collected from projects across the state.

Social science data collection and program evaluation are evolving areas of practice within the field of watershed management. Investments in this work are likely to begin slowly and increase as the need for information and trend analysis data is recognized. It is advisable to take a phased approach to rolling out any new monitoring or program evaluation systems to support grounded and informed decisions that will support long-term institutional and program capacity building in this arena.

Measure Points of Contact

Agency/Affiliation Information

Social Measures Team Members
Margaret Wagner (Chair)
Minnesota Department of Agriculture
Margaret.wagner@state.mn.us

651-201-6488

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

Tannie Eshenaur
Minnesota Department of Health
tannie.eshenaur@state.mn.us

Katherine Logan
Minnesota Pollution Control Agency
katherine.logan@state.mn.us

Barb Radke
Board of Soil and Water Resources
barbara.radke@state.mn.us

Sharon Pfeifer
Minnesota Department of Natural Resources
sharon.pfeifer@state.mn.us

Preparer

Mae Davenport
Department of Forest Resources
University of Minnesota
mdaven@umn.edu

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Lauber, T.B. & Knuth, B.A. (1999). Measuring fairness in citizen participation: A case study of moose management. *Society and Natural Resources, 11*, 19-37.

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Lockwood, M., Davidson, J., Curtis, A., Stratford, E., and Griffith, R. (2010). Governance principles for natural resource management, *Society & Natural Resources*, *23*(10), 986-1001.

Pradhananga, A. & Davenport, M.A. (2013). *A community capacity assessment study in the Minnehaha Creek Watershed, Minnesota*. St. Paul, MN: Department of Forest Resources, University of Minnesota. 64 pp. Retrieved from: http://www.forestry.umn.edu/prod/groups/cfans/@pub/@cfans/@forestry/documents/asset/cfans_asset_442326.pdf

Smith, P.D. & McDonough, M. (2001). Beyond public participation: Fairness in natural resource decision making. *Society and Natural Resources: An International Journal, 14*, 239-249.

Wutich, A., Brewis, A., York, A.M., & Stotts, R. (2013). Rules, norms and injustice: A cross-cultural study of perceptions of justice in water institutions. *Society and Natural Resources: An International Journal, 26*, 795-809.

Appendix B. Resources for Social Assessment

Social science research ethics

- Prokopy, L.S. (2008). Ethical concerns in researching collaborative natural resource management, *Society and Natural Resources: An International Journal*, 21(3), 258-265.
- Sommer, R. & Sommer, B. (2002). *A practical guide to behavioral research: Tools and techniques, 5th ed.* New York, NY: Oxford University Press.

Participatory scoping

Methods:

- National Oceanic and Atmospheric Administration. (n.d.) *Stakeholder engagement strategies for participatory mapping.* Retrieved from: http://www.csc.noaa.gov/digitalcoast/publications/social-science-series
- U.S. Department of Housing and Urban Development. (n.d.) *Connecting to success: Neighborhood networks asset mapping guide*. Retrieved from: http://www.hud.gov/offices/hsg/mfh/nnw/resourcesforcenters/assetmapping.pdf
- Mendelow, A. (1991). "Stakeholder mapping", *Proceedings of the 2nd International Conference on Information Systems*, Cambridge, MA.
- Holley, J. (2012). *Network Weaver Handbook: A Guide to Transformational Networks*. Athens, OH: Network Weaver Publishing
- Dorfman, D. (1998). *Mapping community assets workbook*. Portland OR: Northwest Regional Educational Laboratory. Retrieved from http://www.abcdinstitute.org/docs/Diane%20Dorfman-Mapping-Community-Assets-WorkBook(1)-1.pdf
- Bryson, J., & Carroll, A. (2007). *Public participation fieldbook.* St. Paul, MN: University of Minnesota.

Example projects:

- Big Watershed Game, Neighbors By Way of Water, NorthernLights.mn, Minnehaha Creek Watershed District, Writerguy LLC, MPCA Watershed Division. Contact Cynthia Hilmoe, cynthia.hilmoe@state.mn.us.
- Root River, Fillmore Co. SWCD. Contact Cynthia Hilmoe, cynthia.hilmoe@state.mn.us.
- Rum River, Mille Lacs Co. Contact Cynthia Hilmoe, cynthia.hilmoe@state.mn.us.
- Watonwan River Major Watershed Project. Contact Cynthia Hilmoe, cynthia.hilmoe@state.mn.us.

Secondary data analysis methods

- McDermaid, K.K. (2006). *A step-by-step guide to conducting a social profile for watershed planning*. Champaign, IL: University of Illinois. http://www.watershedplanning.illinois.edu/index.html

Observation methods

- Mack, N., Woodsong, C., MacQueen, K.M., Guest, G. & Namey, E. (2005). *Qualitative research methods: A data collector's field guide*. Report to U.S. Agency for International Development, Family Health International, pp. 136. Retrieved

from: http://www.nucats.northwestern.edu/community-engaged-research/seminar-series-and-events/pdfs/Family_Health_International_Qualitative_Research_Methods.pdf
- Sommer, R. & Sommer, B. (2002). *A practical guide to behavioral research: Tools and techniques, 5th ed.* New York, NY: Oxford University Press.

Focus groups

Methods:

- Krueger, R.A., & Casey, M.A. 2000. *Focus groups: A practical guide for applied research*. Thousand Oaks, California: Sage Publications.
- Mack, N., Woodsong, C., MacQueen, K.M., Guest, G. & Namey, E. (2005). *Qualitative research methods: A data collector's field guide*. Report to U.S. Agency for International Development, Family Health International, pp. 136. Retrieved from: http://www.nucats.northwestern.edu/community-engaged-research/seminar-series-and-events/pdfs/Family_Health_International_Qualitative_Research_Methods.pdf
- National Oceanic and Atmospheric Administration. (n.d.) Introduction to conducting focus groups. Retrieved from: http://www.csc.noaa.gov/digitalcoast/publications/social-science-series
- Nickerson, R., Anderson, D.H., Davenport, M.A., Leahy, J.E., & Stein, T.V. (2006). *Gathering visitor and community benefit data for managing recreation areas: A manager's guide*. St. Paul, MN: University of Minnesota, Department of Forest Resources, 206 pp.
- Sommer, R. & Sommer, B. (2002). *A practical guide to behavioral research: Tools and techniques, 5th ed.* New York, NY: Oxford University Press.

Example projects:

- Lewandowski, A. (2010). Review of conservation drainage practices and designs in Minnesota. St. Paul, MN: University of Minnesota
- Davenport, M.A. & Olson, B. (2012). *Nitrogen use and determinants of best management practices: A study of Rush River and Elm Creek watershed agricultural producers*. St. Paul, MN: Department of Forest Resources, University of Minnesota. 78 pp. http://www.forestry.umn.edu/prod/groups/cfans/@pub/@cfans/@forestry/documents/article/cfans_article_416043.pdf
- Mountjoy, N. J., E. Seekamp, M. A. Davenport and M. R. Whiles. (2013). Identifying capacity indicators for community-based natural resource management initiatives: Focus group results from conservation practitioners across Illinois. *Journal of Environmental Planning and Management*. DOI:10.1080/09640568.2012.743880.
- Mountjoy, N.J., Seekamp, E. Davenport, M.A., & Whiles, M.R. (2011). *Making conservation work: Ideas from on-the-ground practitioners*. Research Publication, Carbondale, IL: Southern Illinois University, Department of Zoology and Center for Ecology.

Surveys

Methods:

- National Oceanic and Atmospheric Administration. (n.d.) Introduction to survey design and delivery. Retrieved from: http://www.csc.noaa.gov/digitalcoast/publications/social-science-series

- Nickerson, R., Anderson, D.H., Davenport, M.A., Leahy, J.E., & Stein, T.V. (2006). *Gathering visitor and community benefit data for managing recreation areas: A manager's guide*. St. Paul, MN: University of Minnesota, Department of Forest Resources, 206 pp.
- Sommer, R. & Sommer, B. (2002). *A practical guide to behavioral research: Tools and techniques, 5th ed.* New York, NY: Oxford University Press.
- Vaske, J.J. (2008). *Survey research and analysis: Application in parks, recreation and human dimensions*. State College, PA: Venture Publishing.

Example projects:

- Davenport, M.A., & Pradhananga, A. (2012). *Perspectives on Minnesota water resources: A survey of Sand Creek and Vermillion River watershed landowners*. St. Paul, MN: Department of Forest Resources, University of Minnesota. 84 pp. http://www.forestry.umn.edu/prod/groups/cfans/@pub/@cfans/@forestry/documents/asset/cfans_asset_379379.pdf
- Eckman, K., Brady, V., Schomberg, J., Were, V. (2011). *The lakeside stormwater reduction project (LSRP): Evaluating the impacts of a paired watershed study on local residents*. Retrieved from: http://files.dnr.state.mn.us/eco/nsbi/lsrp_final_report_july26_2011.pdf
- Davenport, M.A., Trushenski, J., & Whitledge, G. (2010). *Illinois boaters' beliefs and practices associated with fish diseases and aquatic invasive species*. Research Publication, St. Paul, MN: University of Minnesota, Department of Forest Resources, 86 pp. http://www.forestry.umn.edu/prod/groups/cfans/@pub/@cfans/@forestry/documents/asset/cfans_asset_409269.pdf

Interviews

Methods:

- Mack, N., Woodsong, C., MacQueen, K.M., Guest, G. & Namey, E. (2005). *Qualitative research methods: A data collector's field guide*. Report to U.S. Agency for International Development, Family Health International, pp. 136. Retrieved from: http://www.nucats.northwestern.edu/community-engaged-research/seminar-series-and-events/pdfs/Family_Health_International_Qualitative_Research_Methods.pdf
- Seidman, I. 2006. *Interviewing as qualitative research*. 3rd Ed. New York: Teachers College Press.
- Sommer, R. & Sommer, B. (2002). *A practical guide to behavioral research: Tools and techniques, 5th ed.* New York, NY: Oxford University Press.

Example projects:

- Pradhananga, A. & Davenport, M.A. (2013). *A community capacity assessment study in the Minnehaha Creek Watershed, Minnesota*. St. Paul, MN: Department of Forest Resources, University of Minnesota. 64 pp. Retrieved from: http://www.forestry.umn.edu/prod/groups/cfans/@pub/@cfans/@forestry/documents/asset/cfans_asset_442326.pdf
- Davenport, M.A. (2013). Conservation practice adoption: Motivations and constraints among Lake Nokomis area business owners. A technical report prepared for Metro Blooms, Minneapolis, MN. 27 pp. http://www.metroblooms.org/files/publications/Nokomis%20Busines%20Owner%20Conservation%20Practices%20Davenport%20091913.pdf

- Davenport, M.A. & Olson, B. (2012). *Nitrogen use and determinants of best management practices: A study of Rush River and Elm Creek watershed agricultural producers*. St. Paul, MN: Department of Forest Resources, University of Minnesota. 78 pp. http://www.forestry.umn.edu/prod/groups/cfans/@pub/@cfans/@forestry/documents/article/cfans_article_416043.pdf
- Davenport, M.A., Bridges, C.A., Mangun, J.C., Carver, A.D., Williard, K.W.J., & Jones, E.O. (2010). Building local community commitment to wetlands restoration: A case study of the Cache River Wetlands in southern Illinois, U.S.A. *Environmental Management, 45*(4), 711-723. http://www.forestry.umn.edu/prod/groups/cfans/@pub/@cfans/@forestry/documents/asset/cfans_asset_409265.pdf

Appendix C. Example Assessment Approaches

Community capacity assessment approach:
A community capacity assessment examines assets, needs, capacities and constraints of community engagement in sustainable environmental management. Community capacity encompasses individual, relational, organizational and programmatic capacity (see Figure 1, Davenport & Seekamp 2013). Community capacity assessments can use multiple tools including secondary data analysis, interviews, focus groups, and surveys.

Selected reference:

Pradhananga, A. & Davenport, M.A. (2013). *A community capacity assessment study in the Minnehaha Creek Watershed, Minnesota*. St. Paul, MN: Department of Forest Resources, University of Minnesota. 64 pp. http://www.forestry.umn.edu/prod/groups/cfans/@pub/@cfans/@forestry/documents/asset/cfans_asset_442326.pdf

Knowledge, attitudes and practices (KAP) Study Approach:
A KAP study is a highly focused assessment of people's knowledge, attitudes and practices (KAP) surrounding a specific issue or problem KAP studies are done twice, both prior to and follow intervention (i.e. project, workshop, etc.) and are useful for planning as well as evaluating outcomes. KAP is a relatively simple and flexible approach that can be used with various groups sizes. KAP studies employ surveys and can be used in combination with other assessment tools such as participant observation. KAP is typically a low-cost method. It often starts with a gap analysis, which helps identify gaps in knowledge about an audience. A gap analysis starts with a list of key information that will be needed to evaluate desired outcomes. KAP studies answer questions such as: Does a target audience increase their knowledge of a particular problem? Do their attitudes and opinions change in a positive direction? Does the audience adopt a recommended practice? Is the practice maintained over time?

Selected references:

Eckman, K., Blickenderfer, M. (2012). *Itasca County native shoreland buffer incentive social research report*. Retrieved from: http://wrc.umn.edu/prod/groups/cfans/@pub/@cfans/@wrc/documents/asset/cfans_asset_382146.pdf

Eckman, K., Henry, S. (2012). *East Otter Tail County native shoreland buffer incentive: Social research report*. Retrieved from: http://wrc.umn.edu/prod/groups/cfans/@pub/@cfans/@wrc/documents/asset/cfans_asset_382165.pdf

Eckman, K., Brady, V., Schomberg, J., Were, V. (2011). *The lakeside stormwater reduction project (LSRP): Evaluating the impacts of a paired watershed study on local residents*. Retrieved from: http://files.dnr.state.mn.us/eco/nsbi/lsrp_final_report_july26_2011.pdf

Rapid watershed assessment approach (Natural Resource Conservation Service): Rapid watershed assessments provide initial estimates of where conservation investments would best address the concerns of landowners, conservation districts, and other community organizations and stakeholders. These assessments help land-owners and local leaders set priorities and determine the best actions to achieve their goals.

Socio-economic profile approach: Gather demographic information from area where a project or program will take place to create a socio-economic profile of a community of place.

Selected reference:
McDermaid, K.K. (2006). *A step-by-step guide to conducting a social profile for watershed planning*. Champaign, IL: University of Illinois. http://www.watershedplanning.illinois.edu/index.html

Streamlined stakeholder and community asset assessment: Relatively straightforward and low cost approach to collecting basic information using stakeholder analysis, community asset inventory, social network map and community readiness review can produce relatively quickly using Participatory Scoping methods like those listed above and others. Typically this assessment is repeated iteratively as the project gradually and strategically engages the community in layers moving out from those directly involved in the project to key informants (e.g., stakeholders and community members).

The assessment can be deployed one-on-one or in a workshop setting using worksheets or guided using the worksheets to fashion a script. A power/interest grid can be used to analyze stakeholder roles in the community, providing insight into the function different people may play in preparing for and implementing ongoing community assessment and/or public involvement and civic engagement strategy planning and implementation. Likewise, a community asset map and social network map are conventional means of preparing a simple but useful community assessment. Readiness of the community to engage can be characterized using a 5-stage scheme provided at www.harwoodinstitute.org (Four frameworks).

Selected References:
See references listed under Appendix B for Participatory Scoping

Rapid assessment approach:
Rapid assessments involve a team of researchers to investigate complex social and policy issues (Beebe 2001). James Beebe, a former U.S. Agency for International Development practitioner and leading expert in the field of human organization, defines the rapid assessment process as "intensive, team-based ethnographic inquiry using triangulation, iterative data analysis, and additional data collection to quickly develop a preliminary understanding of a situation from the insider's perspective" (2001, p. 1). This methodology is well-suited for assessments of adaptive capacity in forest-associated communities because of the diversity of stakeholders and perspectives on forest management involved.

Selected references:
Beebe, J. (2001). *Rapid assessment process: An introduction*. Walnut Creek, CA: AltaMira Press.
Davenport, M.A., Sames, A., Bussey, J. Pradhananga, A., Emery, M. & Jakes, P. (forthcoming). *Community capacity to adapt to environmental change: A rapid assessment of a Minnesota forest-associated community*. St. Paul, MN: University of Minnesota, Department of Forest Resources. Retrieved

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