MINNEHAHA CREEK WATERSHED DISTRICT
QUALITY OF WATER QUALITY OF LIFE

MEMORANDUM

To: Board of Managers

From: Yvette Christianson and Kelly Dooley, Water Quality Managers

CC: Lars Erdahl, Craig Dawson

Date: May 6, 2015

RE: **E-GRADE PROGRAM UPDATE**

This memorandum is a periodic update on the progress of the development of criteria and metrics for deep and shallow lakes, streams, and wetlands in the E-Grade Program.

Background: The E-Grade Program is a new grading system that will provide a holistic view of the health of water resources throughout the entire watershed. This program will allow MCWD to better identify water resource areas that need improvement or protection in each of the 11 subwatersheds, and to focus management strategies in these areas. Water Quality and Communications' staff have developed a summary for the introduction and phasing of the E-Grade program across the District (Attachment 1). The new grading system will continue assessments of lakes and will also include additional ecological features and functions (Tables 1-2).

Table 1. Ecological Features Used to Develop the E-Grade Program

Ecological Features
Deep Lakes
Shallow Lakes
Streams
Wetlands
Terrestrial
Groundwater
Hydrology

Table 2. Each Ecological Feature in Table 1 Will Be Assessed on the List of Ecosystem Functions

Ecosystem Functions
Flood Control
Nutrient Cycling
Biodiversity
Habitat Diversity
Recreation
Drinking Water Supply

The E-Grade Program is under development from 2014-2017. During development, the test subwatersheds for the new grading system are the Lower Minnehaha Creek, Schutz Lake, and Six Mile Marsh. These subwatersheds' reports will be released in the fall of 2017. The remaining subwatersheds will be evaluated and graded on a three-year rotation, with the next reports to be released in 2019 and 2022. The watershed-wide report for MCWD will be released in 2023.

Follow-Up Since February 12, 2015 E-Grade Update: The technical advisory committee met on March 18, 2015 to review and discuss a list of chosen indices for the MCWD E-Grade Program and finalize the metrics for some of our other services. MCWD staff and Wenck used the attached technical memorandum and tables (Attachment 2) for the purpose of group discussion. Small sub-group meetings were held on the 8th, 16th, and 20th of April. Members of the technical advisory committee volunteered to participate in the smaller groups as technical experts for specific metrics (i.e. fish index of biological integrity, floristic quality) for lakes, streams, and wetlands.

Next Steps: MCWD staff and consultants will be revising the metrics tables based on the feedback provided by the technical advisory committee and small groups. Staff and consultants will be collecting additional data relating to the gaps identified. This information will then be used to test the metrics within the three subwatersheds. In the testing phase, the following factors will be determined: scale, type of grade, and grade weight. The technical advisory committee will reconvene to provide final comments, once the metrics are completed (expected in July/August).

The Board of Managers can expect a presentation in September of the finalized metrics and scoring for the functions of the ecological features deep and shallow lakes, streams, and wetlands.

If there are questions, please contact:

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ECOSYSTEM EVALUATION PROGRAM

ASSESSING THE WATERSHED'S OVERALL HEALTH

WHAT

To promote greater understanding of the overall health of the lakes, streams and wetlands in the watershed, Minnehaha Creek Watershed District (MCWD) is embarking on an Ecosystem Evaluation Program (E-Grade). Under this new program, which is currently under development, bodies of water and other ecological features in the District will be evaluated for their performance of the following functions:

- Flood control
- Habitat diversity
- Drinking water supply
- Biodiversity
- Recreation
- Nutrient cycling

Instead of solely grading lakes, MCWD will initially assess four ecological features within the District: Deep lakes, shallow lakes, streams and wetlands. Three more ecological features will be added in the future: Land use, groundwater and hydrology.

WHY

The District's current method of grading the health of its waters only gives us a partial snapshot by looking only at three factors: phosphorus, chlorophyll and clarity. This does not consider other indicators of a healthy ecosystem, such as flood control and habitat diversity. The current system only assesses lakes and does not differentiate between deep and shallow lakes, which have different characteristics and functions.

MCWD will use the data collected under the E-Grade program to create a comprehensive report card about the overall health of the watershed's ecosystems. This information will allow the District to better identify high-need areas for improvement or protection, and to focus its management strategies in these areas. It will also help build understanding of the various factors that impact the health of water bodies and other ecological features.

HOW

Because the District will be collecting much more detailed data on the water bodies it is grading, the new program will examine all of the District's subwatersheds on a 10-year cycle, focusing on a group of subwatersheds every three years. The District will continue to regularly monitor all bodies of water in the District for standard parameters (clarity, phosphorus, chlorophyll) through the first 10-year cycle. A full report on the health of the entire watershed will be issued every 10 years.

GROUP 1

Lower Minnehaha Creek
Schutz Lake
Six Mile Marsh

GROUP 2

Dutch Lake
Gleason Lake
Langdon Lake
Long Lake Creek
Painter Creek
Upper Minnehaha Creek

GROUP 3

Christmas Lake
Lake Minnetonka
Lake Virginia

WHEN

NOW
Develop the grading system and collect data for Group 1

2016-2019
Collect data on Group 2

2019-2021
Collect data on Group 3

2023
Release first watershed-wide E-Grade report

2017
Release E-Grade reports for Group 1

2019
Release E-Grade reports for Group 2

2022
Release E-Grade reports for Group 3

FREQUENTLY ASKED QUESTIONS

Why are you changing from the current system?
The MCWD's current Lake Grade system only provides a narrow view of a lake's health. The new program will give a more comprehensive assessment. While the current system only grades lakes, the new system will also evaluate streams and wetlands, and will use different criteria for deep lakes and shallow lakes.

Is the new grading system scientifically sound?
The District developed the program in conjunction with a variety of agencies and technical experts. MCWD plans to publish two papers in peer-reviewed scientific journals, ensuring approval from the greater scientific community.

Will you still be monitoring my lake when it is not in the focus group of subwatersheds?
Yes, District staff will continue to regularly monitor all bodies of water in the District for standard parameters (clarity, phosphorus, chlorophyll) through the first 10-year cycle.

Will you still be releasing lake grades?
Yes, the District will continue to issue lake grades based on standard parameters through the first 10-year cycle.

How will the information be distributed?
The District will release E-Grade report cards detailing the health of the focus subwatersheds every three years. It will also publicize the information with community meetings, outreach to local media, a web page, and a one-page summary of each subwatershed. Every 10 years, the District will release a comprehensive report on the health of the entire watershed.

LEARN MORE

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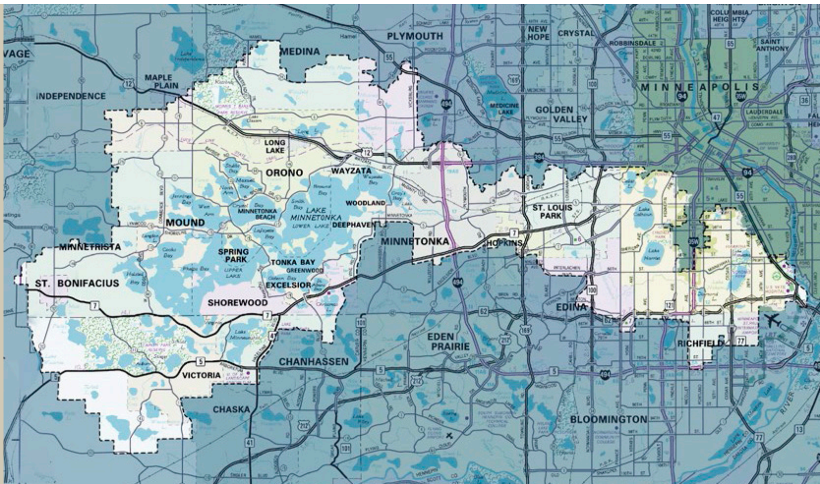

Technical Memo

To: Kelly Dooley, Minnehaha Creek Watershed District
Yvette Christianson, Minnehaha Creek Watershed District

From: Joe Bischoff, Wenck Associates, Inc.
Diane Spector, Wenck Associates, Inc.

Date: March 9, 2015

Subject: E-grade Expanded Metrics Tables

The purpose of this technical memorandum is to relay the draft E-grade expanded metrics tables for the deep and shallow lakes, wetlands, and streams systems and to provide background and discussion points for the next meeting of the Technical Advisory Committee (TAC) on March 18, 2015.

Background

As a reminder, we are using an ecosystems services framework to assess the key features in the target subwatersheds. The six services are:

1. Flood Control
2. Nutrient Cycling
3. Biodiversity
4. Habitat Diversity
5. Recreation
6. Drinking Water Supply

Our initial phase of work is to identify the key components of those ecosystem services for deep and shallow lakes, wetlands, and streams. In a later phase we will assess groundwater, terrestrial systems, and hydrology. For each key component we will identify one or more individual metrics to evaluate how well each system is providing these services.

Metrics Tables

The metrics table for each system is organized by ecosystem service, with the general functions performed by the system described. The different components of those services we call Measures. These are the components that we propose to measure using the specified Metrics to determine the extent to which the lake, stream, or wetland is providing that ecosystem service. We have focused on identifying primary components to simplify the assessment for this first round of E-grading. We are also maximizing the use of existing data or data that can be collected as part of the District's ongoing Hydrodata program or easily developed using GIS or other tools. This format can be expanded in the future should the District want to add additional sub-metrics or keystone species. For each sub-metric we have provided a short rationale to explain why we believe each is an appropriate measure.

As we discussed the selection of these metrics and sub-metrics, we at times found it difficult to discern those that were objective measures of, for example, habitat diversity, and those that were stressors. For example, a wetland outlet structure may provide for open water desirable to waterfowl, but it also can alter the wetland's natural hydroperiod.

Requested TAC Review and Comment

The TAC can provide invaluable advice and assistance general direction and in reviewing and commenting on the draft tables. After the March 18 meeting we suggest establishing some subgroups by system so that those members with specific technical expertise can focus on their specialty areas. After those subgroups have reviewed the metrics in more detail, the TAC can come together again as a whole to move into the next phase of E-grade.

The questions below are those that came up as we were developing these tables. Some of the questions are general and others are specific to a system. A general discussion by the TAC about these issues would be helpful to us as we try to finalize the choice of metrics. Please note that some metrics are left blank for further discussion because they are currently under development or we are looking for more direction on these. If there are metrics the TAC thinks are missing, please be prepared to discuss those at our meeting.

General Questions:

1. Are these the right metrics? There are a number of different ways to assess ecological health. We tried to limit the metrics to those that would address the primary functions of each system. Are there any additional metrics that should be considered, or do you disagree with any of those we have identified?
2. Are we measuring too many things? For some of the tables you will see some metrics on the tables that are crossed out. We would like to discuss these because we aren't convinced whether those should stay in or be dropped.
3. We often bump into questions of scale, especially in considering wetlands. Is this E-grade assessing the health of an individual waterbody, the waterbodies in a subwatershed, or both? If there are thirty wetlands in a subwatershed, does each get an individual score and the subwatershed get a score relating to the quality and distribution of wetlands in the subwatershed? What is the scale of this E-grade?
4. We have defined hydrology as a separate system as it related to quantity, flow, etc. within a subwatershed. However, hydrology is an integral component of many of the proposed metrics.

Lake Questions (Table 1):

1. Should a zooplankton metric be considered at this time?
2. Where do water quality parameters such as chloride fit? Is this a stressor or a measure of lake health?

Wetland Questions (Table 2):

1. Wetland indicators of nutrient cycling including soil health are currently under development by the EPA as a part of their National Wetland Condition Assessment. Should we pursue some of their metrics?
2. Can we limit any of the metrics to simplify the health measure?

Stream Questions (Table 3):

1. There has been discussion about adding metrics of water quality such as nutrient concentration, turbidity, and DO. However, the fish and macroinvertebrate IBIs implicitly reflect water quality. Should water quality be a separate metric?
2. The proposed metrics for the Recreation ecoservice include public access and measures of aesthetics. Should aesthetics even be considered?

Next Steps

Following the review of these metrics, we would like to schedule a few sub-group meetings to hash out the details of the metrics for that watershed feature. Once the metrics are finalized, the TAC can reconvene as a whole and provide final comments.

Table 1. Deep and shallow lakes services, functions, and metrics.

Ecosystem Service	Functions	Measure	Metrics	Discussion
Flood Control	Watershed storage	TBD – Hydrology (2016-2017)		Lakes provide flood storage in watersheds, especially when they have controlled outlets. However, the role of a lake in overall flood storage will be evaluated under the Hydrology ecosystem service evaluation.
Nutrient Cycling	Nutrient sink, source, transformer	Eutrophication indicators	Total Phosphorus	Lakes play a critical role in nutrient cycling in a watershed, typically acting as sinks for nutrients. Furthermore, the ecological health of the lake can be evaluated based on the standard eutrophication parameters of total phosphorus, chlorophyll-a, and Secchi depth. A significant amount of scientific evaluation of these parameters was completed as a part of the development of nutrient standards for lakes in Minnesota (MPCA 2007). These parameters will be used for evaluating the eutrophication health of the lakes; however actual break points will likely be based on state- or region-wide lake conditions. The scale is currently under development.
			Chlorophyll-a	
			Secchi depth	
		Zooplankton (shallow lakes only)	~~Concentration of large daphnia (per liter)~~	Zooplankton, especially large Daphnia, can play a significant role in maintain water clarity in shallow lakes (Hosper and Meijer 1993).
		Sediment chemistry	Redox-P concentration (iron bound, loosely bound, and labile P)	Sediment chemistry, especially the concentration of redox-sensitive phosphorus, is a critical indicator of a lake's ability to sediment and bury phosphorus, ultimately acting as a P sink. In partnership with the University of Wisconsin-Stout, Wenck has collected redox P for over 50 lakes. Wenck will also build a literature database of lake redox P to develop a reference list and breakpoints for determining the health of lake sediments.
Biodiversity	Resilient biological community	Fish IBI	Number of Native Species. This metric is (+) correlated with lake quality.	Indices of Biological Integrity (IBIs) are currently in development for Minnesota lakes by the Minnesota DNR based on previous work (Drake and Pereira 2002; Drake and Valley 2005) conducted by DNR staff. The MNDNR is currently adapting this approach for lake assessment and is applying the indices by lake class (Schupp 1992). Not all of the metrics listed here are included for every lake class. We are currently working with DNR to develop scores for lakes in the test subwatershed.
			Number of Intolerant Species. This metric is (+) correlated with lake quality.	
			Number of Tolerant Species. This metric is (-) correlated with lake quality.	
			Number of Insectivores. This metric is (+) correlated with lake quality.	
			Number of Omnivores. This metric is (-) correlated with lake quality.	
			Number of Cyprinids. This metric is (+) correlated with lake quality.	
			Number of Small Benthic Dwellers. This metric is (+) correlated with lake quality.	
			Number of Vegetation Dwellers. This metric is (+) correlated with lake quality.	
			Ratio of Intolerants in Nearshore. This metric is (+) correlated with lake quality.	
			Ratio of Small Benthic Dwellers in Nearshore. This metric is (+) correlated with lake quality.	
			Ratio of Vegetation Dwellers in Nearshore. This metric is (+) correlated with lake quality.	
			Ratio of Insectivore Biomass in Trapnet. This metric is (+) correlated with lake quality.	
			Ratio of Omnivore Biomass in Trapnet. This metric is (-) correlated with lake quality.	
			Ratio of Tolerant Biomass in Trapnet. This metric is (-) correlated with lake quality.	
			Ratio of Carnivore Biomass in Gillnet. For Group 7 lakes, walleye are excluded from the metric, assuming all are stocked. This metric is (+) correlated with lake quality.	
			Presence or absence of intolerant fish species in the Gillnet. This metric is (+) correlated with lake quality.	

Ecosystem Service	Functions	Measure	Metrics	Discussion
		Floristic Quality	Plant richness	Several plant multimetric indices have been developed for inland wetlands (Wilcox et al.,2002; Miller at al., 2006; Rothrock et al.,2008). Nichols et al. (2000) proposed a multimetric index for Wisconsin lake macrophyte communities based on metrics such as maximum depth of plant growth, percent littoral area vegetated, diversity, taxa richness and relative frequencies of sensitive species. Based on identified shortcomings in these approaches, Radomski and Perleberg (2012) developed an aquatic macrophyte integrity index for Minnesota lakes. We are currently working with Paul Radomski and Donna Perleberg to apply their index to lakes in the test subwatersheds and evaluate their usefulness in assessing the ecological health of the lakes.
			Floristic Quality Index (FQI)	
		Aquatic Invasive Species	Presence/absence and density of zebra mussels.	Zebra mussels can alter the ecological condition of lake ecosystems by altering the food web. However, quantifying these impacts and determining if the zebra mussel infestation will reach sufficient densities to affect the food web is difficult. We are currently further investigating indices for determining zebra mussel impacts. It may be that the metric will be simply a presence or absence notation until the potential impacts are better understood. Carp can alter the ecological condition of shallow likes by limiting aquatic vegetation growth and sustaining the lake in a turbid state. Some care is needed to minimize double counting carp here and in the Fish IBI. Curly-leaf pondweed and Eurasian water milfoil are of special interest to the District and scales may need to be developed for these species.
			Presence/absence and density of carp (shallow lakes).	
			Presence/absence and density of Curly-leaf pondweed.	
			Presence/absence and density of Eurasian watermilfoil.	
Habitat Diversity	Fish, macroinvertebrate, and wildlife habitat	Floristic Quality Index	Species Richness	See above. It is assumed that a high quality vegetation community in the lake littoral zone results in high quality fish habitat. Furthermore, lake fringe wetlands are included in the wetland evaluation for habitat services.
			FQI	
		Shoreline	Fringing Deepwater Habitat (McRAM #22)	Wetlands which lie at the fringe of lakes, deepwater habitats, and along watercourses provide habitat for species that use open water habitats.
			Rooted shoreline vegetation (macrophyte cover along shoreline - McRAM #23)	The greater density of macrophytes along the shoreline, the greater the protection from erosion, and presumably the better the habitat.
			Width of wetland between shoreline/streambank and deepwater/stream. (McRAM #24)	Wider wetlands along lakes and streams are more likely to dissipate wave energy and stabilize sediments. Presumably, a wider wetland will also provide better habitat for certain organisms.
			Adjacent buffer land cover/land use (average width of naturalized buffer within 500 ft). Different scales given for water quality, wildlife habitat. (MnRAM #23)	Vegetated buffers provide wildlife habitat, erosion protection, and reduction in surface water runoff. (Different land cover/land use categories determine value for wildlife habitat.)
		Connectivity (# of culverts, dams, etc.)	Percent of connections to other lakes impeded by a culvert, dam or other water control structure.	Connectivity of lakes is important for fish migration and supporting habitat.
Public Recreation	Access	Public access	Presence/absence of public access(boat ramp, fishing pier, marinas, swimming beach)	The presence or absence of public access (boat ramp, fishing pier, marinas, swimming beach) is a good indicator of providing recreational services.
	Water Quality	Eutrophication and bacteria	Total phosphorus	The swimmability of the lake is measured by the eutrophic state including the probability of toxic algae blooms that may limit swimming safety. Bacteria concentrations at high enough levels can limit recreational use and result in beach closures.
			Chlorophyll-a	
			E. Coli or Fecal Coliform counts	

Ecosystem Service	Functions	Measure	Metrics	Discussion
Drinking Water Supply	Groundwater recharge	TBD – (2016-2017)		Lakes may provide significant groundwater recharge to regional aquifers. However, this will be further evaluated under the groundwater ecosystem services assessment.

Table 2. Wetland services, functions, and metrics.

Ecosystem Service	Functions	Measure	Metrics	Discussion
Habitat Diversity	Resilient biological community (wetland scale), food, nesting, refuge, shoreline protection	Vegetation	RFQA-wC Score	The RFQA is preferred over the McRAM section for vegetative diversity because it adds resolution without sacrificing efficiency. Once the average wC score has been calculated for each community in a sampled wetland, a condition category (Exceptional, Good, Fair, Poor) is assigned to each community. The RFQA also yields information on species richness, introduced species richness, and introduced species cover.
			RFQA-Vegetation Community Interspersion (Horizontal)	For sampled wetlands, interspersion of communities within wetlands is an important feature of wildlife habitat value as diverse habitats generally support more diverse assemblages of wildlife. (Horizontal heterogeneity.)
			RFQA-Vegetation Strata (Vertical)	Wetlands dominated by forested or scrub-shrub vegetation are more likely to support a notable on-site diversity and/or abundance of migrating and wintering wetland-dependent birds. (Adamus 1991; Section 3.9, predictor #12.)
			RFQA-Vegetation Class	In sampled wetlands, identification of Eggers and Reed plant community type and % cover will help determine interspersion and strata (submetric nos. 2, & 3), proximity to other wetlands of same or different type (submetric #9).
			Vegetation Class (McRAM #5)	For wetlands not sampled, the McRAM vegetation class (McRAM #5) previously assigned will help determine interspersion and strata (submetric nos. 2 & 3), and proximity to other wetlands of the same or different type (submetric #9).
			RFQA-Vegetation Strata	A score will be given to each wetland based on the number of vegetation communities and interspersion of communities, with a higher score assigned to wetlands with multiple vegetation communities.
			Water-Vegetation Interspersion (McRAM #9 - horizontal)	For wetlands not sampled, answers to McRAM #9 in existing database could be used to determine horizontal interspersion of communities. Horizontal heterogeneity is an important feature of wildlife habitat value, as diverse habitats generally support more diverse assemblages of wildlife.
Biodiversity	Resilient biological community (watershed scale), shoreline protection	Connectivity	Barriers (McRAM #39)	Habitat value diminishes when fragmented by barriers that restrict wildlife migration and movement.
			Proximity to other wetlands of same or different type (RFQA, GIS)	Adamus (1991), section 3.9, predictor #38: Proximity of wetlands of different types favors greater bird diversity.
			Width and continuity of unmanicured upland buffer (McRAM #16 (MnRAM #24))	A wetland surrounded by full, unmanicured vegetative cover likely has better water quality than a wetland surrounded by manicured turf, bare soil, pavement, etc.
			Adjacent buffer width (average width of naturalized buffer within 500 ft). Different scales given for water quality, wildlife habitat. (MnRAM #23)	Vegetated buffers provide wildlife habitat, erosion protection, and reduction in surface water runoff. (Different scales determine value for water quality and wildlife habitat.)
			Contiguity with Permanent Waterbody (McRAM #43)	A wetland contiguous or intermittently contiguous with a permanent waterbody or watercourse may provide spawning/nursery habitat for native fish species.
			Fringing Deepwater Habitat (McRAM #22)	Shoreline protection only applies to wetlands which lie at the fringe of lakes, deepwater habitats, and along watercourses. Benefit to biodiversity? Should this question be asked for lakes and streams?
			Outlet Type/Hydrology/Flooding (McRAM #6)	The ability of a wetland to maintain a hydrologic regime characteristic of the

Ecosystem Service	Functions	Measure	Metrics	Discussion
				wetland type is somewhat dependent on whether a natural outlet is present, or whether an outlet has been constructed by humans.
		Size	Wetland Size (GIS, McRAM #40)	Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species.
		Proximity	Proximity of wetlands of different types (hydroperiods). (RFQA, GIS)	Snodgrass et al.(2000) find that a watershed with wetlands of a range hydroperiods, from short to long, increases the likelihood of having a greater number of amphibian species.
		Shoreline protection	Rooted shoreline vegetation (macrophyte cover along shoreline - McRAM #23)	The greater density of macrophytes along the shoreline, the greater the protection from erosion, and presumably the better the habitat.
			Width of wetland between shoreline/streambank and deepwater/stream. (McRAM #24)	Wider wetlands along lakes and streams are more likely to dissipate wave energy and stabilize sediments. Presumably, then, a wider wetland will also provide better habitat for certain organisms.
		Land use	Adjacent land use (GIS?)	Adamus (1991) associates certain land uses (industry, landfill, ag, heavily traveled roads) with the likely runoff of contaminants into wetlands. This could affect water quality and therefore biodiversity.
		Water:Vegetation proportion	Water:vegetation proportion (RFQA?)	According to Adamus (1991), even proportions of water and wetland vegetation support greater biodiversity.
Nutrient Cycling	Nutrient sink, source, transformer	Vegetation	Percentage of woody, emergent, submergent, or floating-leaved vegetation. (MnRAM #16.)	A wetland's ability to uptake and remove nutrients and imported elements is primarily dependent on the vegetative conditions of the wetland. Density of vegetation is considered "an index of primary production, which is an indicator of nutrient assimilation."
			Vegetative Cover (RFQA, McRAM #20)	Wetlands with excessive nutrient loading will exhibit algal blooms or the production of monotypic stands of invasive or weed species. The type of vegetative cover within a 50 foot buffer of the wetland boundary is directly related to the efficiency of nutrient cycling within the wetland. Additionally, detritus or vegetative litter in various stages of decomposition is a sign of a healthy wetland.
			Decomposition of litter (McRAM #37)	A healthy wetland will have litter in several stages of decomposition present. Describe the litter condition in the wetland.(Not for wetland types 4, 5 or 8.) Detritus is "essential to nutrient cycling," which affects the plant and animal communities present. "The integrity of the system's vegetation components supplies the bulk of the faunal habitat requirements."
			Adjacent area management for water quality (MnRAM #24)	The average condition of vegetation within 50 feet around the wetland is a predictor of water quality. A wetland surrounded by an area of full, unmanicured vegetation will likely have poorer water quality than a wetland surrounded by manicured lawn, bare soil, pavement, etc.
		Connectivity	Stormwater pretreatment (McRAM #21)	Wetlands that receive untreated, directed stormwater containing sediment and nutrients will not be as sustainable as in a native landscape. Wetlands receiving stormwater with just sediment removal treatment will be subject to nutrient loading and excessive plant growth.
		Land use	Dominant land use and condition of upland watershed or within 500 feet (Lee et al. 1997) (McRAM #11);	Watershed and subwatershed upland land use affects flow of runoff to wetland. The more intense the upland land use, the more runoff [and presumably nutrients] the wetland is likely to receive.
			Adjacent area management: average condition of vegetative cover for water quality, within 50 feet surrounding wetland assessment area. (MnRAM #24)	A wetland surrounded by full, unmanicured vegetative cover likely has better water quality than a wetland surrounded by manicured turf, bare soil, pavement, etc.

Ecosystem Service	Functions	Measure	Metrics	Discussion
Flood Control	Watershed storage	Vegetation	Percentage of woody, emergent, submergent, or floating-leaved vegetation. (MnRAM #16.)	Rooted vegetation in flow-through wetlands slows floodwaters by creating frictional drag in proportion to stem density, more or less according to vegetation cover type and interspersion. Flow-through wetlands with relatively low proportions of open water to rooted vegetation and low interspersion of water and rooted vegetation are more capable of altering flood flows. Dense stands of rooted vegetation, including trees, shrubs, and herbaceous emergent are more capable of slowing floodwater than open water alone.
			Dominant land use and condition of upland watershed or within 500 feet (Lee et al. 1997) (McRAM #11)	Watershed and subwatershed upland land use affects flow of runoff to wetland. The more intense the upland land use, the more runoff the wetland is likely to receive, and the more likely it will minimize downstream flooding.
		Wetland Density	Proportion of wetlands within the subwatershed. (GIS, McRAM #21)	"Wetlands reduce flood peaks up to 75 percent compared to rolling topography when they occupy only 20% of the total basin. When wetland densities in the minor watershed exceed 20% total cover, the flood storage benefits of additional wetlands rapidly decrease.
Drinking water supply	Groundwater recharge	TBD	TBD	TBD

Minnehaha Creek Watershed District
E-Grade Preliminary Metrics - Streams

Table 3. Stream services, functions, and metrics.

Ecosystem Service	Function	Measure	Metric	Discussion
Habitat Diversity	Resilient biological community, food, nesting, refuge, streambank protection	Habitat complexity - Minnesota Stream Habitat Assessment (MSHA)	(MSHA) - Instream Zone (see attached)	In-stream habitat complexity promotes species richness and abundance. This subsection of the MSHS evaluates number and types of substrate, embeddedness, siltation, cover type, and amount of cover. This assumes that habitat complexity is provided by a variety and abundance of substrates, habitat types, and covers.
			MSHA - Riparian Zone (see attached)	The nature of the riparian zone directly influences stream stability and water quality and temperature. It also influences inputs of leaf litter and coarse and fine woody debris. The riparian zone is defined in MSHS as the area of undisturbed vegetation adjacent to the stream.
			MSHA-Channel Morphology (see attached)	A measure of physical stream characteristics that also provide habitat complexity, including quality of pools and rifles, variability in depths, variability in flows, and complexity of channel form. This assumes that habitat complexity increases with greater heterogeneity of stream form and a variety of flows.
		Connectivity	MSHA-Surrounding Land Use (see attached)	The type of land use beyond the immediate riparian zone can influence stream stability and water quality, provide habitat for organisms that require both aquatic and terrestrial cover during their life cycle or which are prey for aquatic organisms, and provide protected corridors for migration.
Biodiversity	Resilient biological community	F-IBI	See attached	Aquatic biota are responsive to stream conditions and community composition reflects the impacts of disturbance over time. IBIs are composed of a set of metrics unique to ecoregion and stream size and gradient. These metrics represent different aspects of ecological structure and function and respond in predictable ways to disturbance. The metrics are scored numerically to quantify deviation from least-disturbed conditions, and summed together producing a composite IBI score that characterizes biological integrity.
		M-IBI	See attached	
Nutrient Cycling	Nutrient sink, source, transformer	Vegetative uptake	MSHA - Aquatic Vegetation (see attached)	Presence and abundance of beneficial aquatic vegetation provides nutrient cycling by vegetative uptake.
		Nutrient cycling – M-IBI	Taxa richness of Plecoptera	Abundance of collector-gatherers can increase the rate of nitrogen cycling and shorten spiral length and increasing productivity (Grimm 1988). These metrics of richness and community composition are negatively correlated with stream biotic integrity.
			Taxa richness of Trichoptera	
			Relative abundance (%) of collector-filterer individuals in a subsample	
			Relative percentage of taxa belonging to Trichoptera	
			Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (baetid taxa treated as one taxon)	
Recreation	Recreation, food, aesthetic or spiritual enjoyment	Access	Riparian public land (GIS)	Public property such as a park or corridor allows users to access the stream for viewing, fishing, accessing for canoeing/kayaking, wading or swimming.
			Public launch or access (GIS)	A public access allows use of the stream for viewing, fishing, canoeing, kayaking, wading or swimming.
		Aesthetics	TBD	TBD
Drinking Water Supply	Groundwater recharge	TBD	TBD	TBD
Flood Control	Conveyance	TBD - Hydrology (2016-2017)	TBD - Hydrology (2016-2017)	Some of the questions raised during this phase that will be explored in later discussions of hydrology include maintenance of biological base flow; flow regime-ecological response relationships considering a recent area of hydrologic and flow studies called ELOHA - Ecological Limits of Hydrologic Alteration; and research done assessing the relationship between acres of wetland in subwatersheds and flow conditions in the subwatershed's streams.

MPCA STREAM HABITAT ASSESSMENT (MSHA)

(revised April 2014)

MSHA SCORE ☐ Max=100

1. Stream Documentation

Field Number: __________ Stream Name: __________ Date: __________

Person Scoring: __________ Water Level (circle one): Flood / High / Normal / Low / Interstitial

2. Surrounding Land Use (Streams) or Floodplain Quality (Rivers)

(check the most predominant or check two and average scores) **[L=left bank/R =right bank, facing downstream]**

L	R			L	R		
☐	☐	Forest, Wetland, Prairie, Shrub	[5]	☐	☐	Diked Wetland	[2]
☐	☐	Old Field/Hay Field	[3]	☐	☐	Urban/Industrial	[0]
☐	☐	Fenced Pasture	[2]	☐	☐	Open Pasture	[0]
☐	☐	Residential/Park	[2]	☐	☐	Mining/Construction	[0]
☐	☐	Conservation Tillage, No Till	[2]	☐	☐	Row Crop	[0]

Land Use ☐ Max=5

3. Riparian Zone (check the most predominant)

A. Riparian Width

L	R			
☐	☐	Extensive	> 100 m	[5]
☐	☐	Wide	50-100 m	[4]
☐	☐	Moderate	10-50 m	[3]
☐	☐	Narrow	5-10 m	[2]
☐	☐	Very Narrow	1-5 m	[1]
☐	☐	None		[0]

B. Bank Erosion

L	R			
☐	☐	None		[5]
☐	☐	Little	5-25%	[4]
☐	☐	Moderate	25-50%	[3]
☐	☐	Heavy	50-75%	[1]
☐	☐	Severe	75-100%	[0]

C. Shade

L	R			
☐	☐	Heavy	>75%	[4]
☐	☐	Substantial	50-75%	[3]
☐	☐	Moderate	25-50%	[2]
☐	☐	Light	5-25%	[1]
☐	☐	None		[0]

Riparian ☐ Max=14

4. Instream Zone

A. Substrate (check two for each channel type)

	Boulder [10]	Cobble [9]	Gravel [8]	Sand [6]	Clay [5]	Bedrock [5]	Silt [2]	Muck [1]	Detritus [1]	Sludge [0]	Channel Type %
Pool	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	____
Riffle	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	____
Run	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	____
Glide	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	____
Note	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Presence

B. Embeddedness

- ☐ None [5]
- ☐ Light 25-50% [3]
- ☐ Moderate 50-75% [1]
- ☐ Severe 75-100% [-1]
- ☐ No coarse substrate [0]

C. Siltation

- ☐ Silt Free [1]
- ☐ Silt Normal [0]
- ☐ Silt Moderate [-1]
- ☐ Silt Heavy [-2]

D. Substrate Types

- ☐ ≥4 [2]
- ☐ <4 [0]

Substrate ☐ Max=28

E. Cover Type (check all that apply)

- ☐ Undercut Banks [1]
- ☐ Overhanging Vegetation [1]
- ☐ Deep Pools [1]
- ☐ Logs or Woody Debris [1]
- ☐ Boulders [1]
- ☐ Rootwads [1]
- ☐ Oxbows, Backwaters [1]
- ☐ Shallows (in slow water) [1]
- ☐ Macrophytes [1]
  - ☐ Submergent
  - ☐ Emergent
  - ☐ Floating Leaf

F. Cover Amount (check one)

- ☐ Extensive >50% [9]
- ☐ Moderate 25-50% [7]
- ☐ Sparse 5-25% [3]
- ☐ Nearly Absent [0]
- ☐ Choking Vegetation only [-1]

Cover ☐ Max=18

5. Channel Morphology

A. Depth Variability

- ☐ Greatest Depth >4X Shallow Depth [4]
- ☐ Greatest Depth 2-4X Shallow Depth [2]
- ☐ Greatest Depth <2X Shallow Depth [0]

B. Channel Stability

- ☐ High [9]
- ☐ Moderate/High [6]
- ☐ Moderate [3]
- ☐ Low [0]

C. Velocity Types (check all that apply)

- ☐ Fast [1]
- ☐ Moderate [1]
- ☐ Slow [1]
- ☐ Eddies [1]
- ☐ Torrential [-1]
- ☐ None [-1]
- ☐ Interstitial [-1]
- ☐ Intermittent [-2]

D. Sinuosity

- ☐ Excellent [4]
- ☐ Good [3]
- ☐ Fair [2]
- ☐ Poor [0]

E. Pool Width/Riffle Width

- ☐ Pool Width > Riffle Width [2]
- ☐ Pool Width = Riffle Width [1]
- ☐ Pool Width < Riffle Width [0]
- ☐ No Riffle [0]
- ☐ No Pool [0]
- ☐ Impounded [-2]

F. Channel Development

- ☐ Excellent [9]
- ☐ Good [6]
- ☐ Fair [3]
- ☐ Poor [0]

G. Modifications (check all that apply)

- ☐ Leveed [-1]
- ☐ Dredged [-1]
- ☐ Bank Shaping [-1]
- ☐ Railroad Ties [-1]
- ☐ Cemented [-2]
- ☐ Bulkheads [-2]
- ☐ Rip Rap [1]
- ☐ Const. Island [1]
- ☐ Wood Pilings [1]

Channel ☐ Max=35

Aquatic Vegetation (indicate as follows for observed abundance: Abundant=[3]; Moderate=[2]; Sparse=[1])

A. Beneficial Aquatic Vegetation

____ Pond Lilies (*Nymphaea*/*Nuphar*)	____ Sedge (*Cyperaceae*)	____ Wild Celery (*Vallisneria*)
____ Wild Rice (*Zizania*)	____ Pond Weed (*Potamogeton*)	____ Bulrush (*Scirpus*)
____ Waterweed (*Elodea*)	____ Coontail (*Ceratophyllum*)	____ Water Cress (*Nasturtium*)

B. Invasive and Negative Aquatic Vegetation

____ Eurasian Milfoil (*Myriophyllum*)	____ Purple Loosestrife (*Lythrum*)	____ Reed Canary Grass (*Phalaris*)
____ Cattails (*Typha*)	____ Duckweed (*Lemna*)	____ Algae (Floating Mats)
____ Algae (Planktonic)	____ Algae (Benthic)	

No Vegetation Noted ☐

Comments: ____

Minnesota Macroinvertebrate IBI Individual Metrics

Invertebrate Class 5 – Southern Streams (Riffle/Run Habitats)
Minnehaha Creek: Falls to the Mississippi; Browndale Dam to Chain of Lakes
Schutz Creek, a few Six Mile Creek reaches

Metric Name	Category	Response	Metric Description
ClimberCh	Habitat	Decrease	Taxa richness of climbers
ClingerChTxPct	Habitat	Decrease	Relative percentage of taxa adapted to cling to substrate in swift flowing water
DomFiveChPct	Composition	Increase	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
HBI_MN	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
InsectTxPct	Composition	Decrease	Relative percentage of insect taxa
Odonata	Richness	Decrease	Taxa richness of Odonata
Plecopotera	Richness	Decrease	Taxa richness of Plecoptera
PredatorCh	Trophic	Decrease	Taxa richness of predators
Tolerant2ChTxPct	Tolerance	Increase	Relative percentage of taxa with tolerance values equal to or greater than 6, using MN TVs
Trichoptera	Richness	Decrease	Taxa richness of Trichoptera

Invertebrate Class 6 – Southern Forest Streams (Glide/Pool Habitats)
Minnehaha Creek between Chain of Lakes & Falls
Most Six Mile Creek reaches

Metric Name	Category	Response	Metric Description
ClingerCh	Habitat	Decrease	Taxa richness of clinger taxa
Collector-filtererPct	Trophic	Decrease	Relative abundance (%) of collector-filterer individuals in a subsample
DomFiveChPct	Composition	Increase	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
HBI_MN	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
Intolerant2Ch	Tolerance	Decrease	Taxa richness of macroinvertebrates with tolerance values less than or equal to 2, using MN TVs
POET	Richness	Decrease	Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (baetid taxa treated as one taxon)
PredatorCh	Trophic	Decrease	Taxa richness of predators
TaxaCountAllChir	Richness	Decrease	Total taxa richness of macroinvertebrates
TrichopteraChTxPct	Composition	Decrease	Relative percentage of taxa belonging to Trichoptera
TrichwoHydroPct	Composition	Decrease	Relative abundance (%) of non-hydropsychid Trichoptera individuals in subsample

Fish-Northern Streams

Minnehaha Creek

Metric Name	Category	Response	Metric Description
DarterSculpSucTXPct	composition	positive	Relative abundance (%) of taxa that are darters, sculpins, and round-bodied suckers
DetNWQPct	trophic	negative	Relative abundance (%) of individuals that are detritivorous
General	trophic	negative	Taxa richness of generalist species
Insect-TolTXPct	trophic	positive	Relative abundance (%) of taxa that are insectivorous (excludes tolerant species)
IntolerantPct	tolerance	positive	Relative abundance (%) of individuals that are intolerant
MA>3-TolPct	reproductive	positive	Relative abundance (%) of individuals with a female mature age >=3 (excludes tolerant taxa)
SensitiveTXPct	tolerance	positive	Relative abundance (%) of taxa that are sensitive
SLithopPct	reproductive	positive	Relative abundance (%) of individuals that are simple lithophilic spawners
SSpnTXPct	reproductive	negative	Relative abundance (%) of taxa that are serial spawners (multiple times per year)
Vtol	tolerance	negative	Number of taxa that are very tolerant
DomTwoPct	dominance	negative	Combined relative abundance of two most abundant taxa
FishDELTPct	tolerance	negative	Relative abundance (%) of individuals with Deformities, Eroded fins, Lesions, or Tumors

Fish-Low Gradient

Six Mile Creek, Schutz Creek

Metric Name	Category	Response	Metric Description
Hdw-TolPct	habitat	positive	Relative abundance (%) of individuals that are headwater species (excludes tolerant species)
Minnows-TolPct	composition	positive	Relative abundance (%) of individuals that are Cyprinids (excludes tolerant species)
NumPerMeter-Tolerant	composition	positive	Number of individuals per meter of stream sampled (excludes tolerant species)
OmnivoreTXPct	trophic	negative	Relative abundance (%) of taxa that are omnivorous
PioneerTXPct	lifehistory	negative	Relative abundance (%) of taxa that are pioneers
Sensitive	tolerance	positive	Taxa richness of sensitive species
SLithop	reproductive	positive	Taxa richness of simple lithophilic spawning species
TolTXPct	tolerance	negative	Relative abundance (%) of taxa that are tolerant
Wetland-Tol	habitat	positive	Taxa richness of wetland species (excludes tolerant species)
FishDELTPct	tolerance	negative	Relative abundance (%) of individuals with Deformities, Eroded fins, Lesions, or Tumors