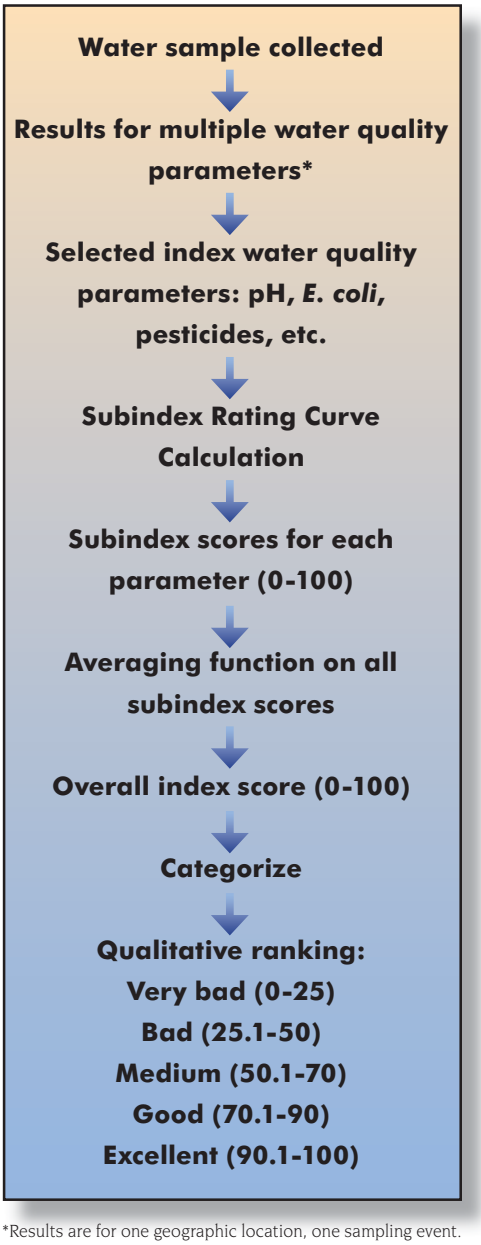
February 2006 Water Fact Sheet 2006-8

IOWA'S WATER
Ambient Monitoring Program

Why a Water Quality Index?

For many years indices such as the Gross National Product and NASDAQ have been used to combine a multitude of economic data to rate the health of the United States economy. Just as one can't gage the health of the economy without combining many pieces of information, one can't gage the health of a stream without looking at data collectively. Water quality monitoring networks collect thousands of chemical, physical, and biological measurements of water each year. Individually, these data do not give us an indication of trends in water quality over time and across geographic areas. A concise, quick way to draw meaning from these numbers is needed. Water quality indices provide a way to distill thousands of records of environmental data into meaningful values that indicate the health of water resources and create a yardstick for measuring and assessing water quality.

In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a stream with a single number. That number is placed on a relative scale that rates the water quality in categories ranging from very bad to excellent. Figure 1 illustrates how index values are calculated. Index values are determined by transforming selected water quality parameters (that have different units of measurement; e.g. mg/L) into a *unitless* subindex value via a subindex rating curve. Each parameter has its own rating curve (on a scale of increasing water quality from 0 to 100) depending on what values for that parameter are considered "good" and "bad" (Figure 2). The objective of the rating curve is to link a parameter's concentration to water quality. After subindices for each parameter are calculated by a rating curve, they are averaged to give an overall water quality index value.



*Results are for one geographic location, one sampling event.

Figure 1. *Process of index calculation.*

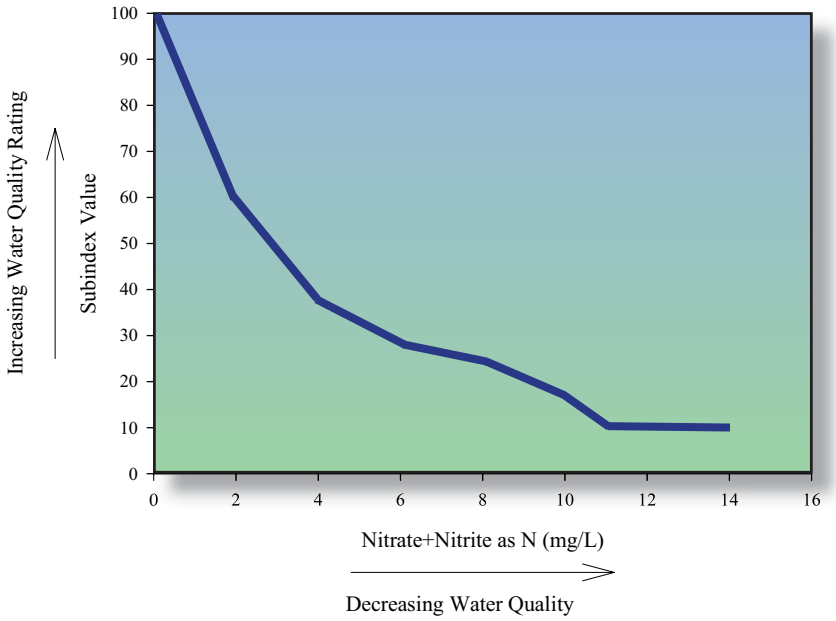


Figure 2. *Example of a subindex rating curve for the Iowa Water Quality Index. Subindex water quality ratings are as follows:* 0-25 (*very bad*), 25.1-50 (*bad*), 50.1-70, (*medium*), 70.1-90 (*good*), 90.1-100 (*excellent*).

National Sanitation Foundation Water Quality Index

The National Sanitation Foundation Water Quality Index (NSFWQI) is the most respected and utilized water quality index in the U.S. However, this index has been criticized for not adequately representing water quality in all areas of the U.S. The "one size fits all" structure of the index causes some regional water quality concerns to be overlooked in the overall index value. The NSFWQI also uses a mathematical averaging function that tends to suggest better water quality than actual conditions.

These shortcomings became apparent when the NSFWQI was applied to four years of monthly stream data collected as part of the Iowa Department of Natural Resources Ambient Water Monitoring Program (2000-2003). Based on the NSFWQI, 79% of Iowa's streams had medium water quality while 21% had good water. This assessment is misleading, as approximately 25% of Iowa's assessed rivers and streams are listed as impaired for their designated use; it follows that not all of Iowa's waters would be rated as having medium and good water quality. A more accurate depiction of Iowa's water quality would include waters that are rated as bad or very bad and some classified as excellent. It was determined that the reasons for this inadequate assessment of Iowa's water quality were due to design failures in the NSFWQI. Therefore, in 2005, the Iowa Water Quality Index (IWQI) was developed as a geographically specific water quality index to represent a full range of water quality conditions in Iowa.

Iowa Water Quality Index: An Improved Index

The IWQI was created by "custom fitting" the NSFWQI to adequately reflect the water quality conditions of Iowa. This geographically specific index ensures that Iowa's unique geographical characteristics will be properly reflected in the water quality index. Such an index is a vital tool in the analysis of local and regional water monitoring and protection programs and policies.

The IWQI rates water quality using the following nine parameters: biological oxygen demand, dissolved oxygen, *E.coli* bacteria, nitrate+nitrite as nitrogen, total detected pesticides, pH, total phosphorus, total dissolved solids, and total suspended solids. The addition of total suspended solids and total

Parameters Included	NSFWQI	IWQI
Biological Oxygen Demand	X	X
Dissolved Oxygen	X	X
E.coli		X
Fecal coliforms	X	
Nitrate - N	X	
Nitrate+Nitrite - N		X
Pesticides		X
pH	X	X
Water Temperature	X	
Total Dissolved Solids	X	X
Phosphorus	X	X
Total Suspended Solids		X
Turbidity	X	
Averaging Function	*Weighted linear sum	**Unweighted harmonic square mean

X = parameter used in index calculation

*Weights are associated with each parameter. The overall index is calculated by the sum of the all of the products of the parameter weights and subindex values.

**No weights associated with each parameter. The overall index score is calculated by the square root of the number of subindices divided by the sum of the reciprocal of the squares of the subindex values.

Table 1. *Major differences between the* National Sanitation Foundation Water Quality Index (NSFWQI) *and the* Iowa Water Quality Index (IWQI). *Subindex rating curves were different for all listed parameters for each of the indices.*

pesticides to the index incorporates water quality concerns specific to nonpoint source pollution that have not been addressed in the NSFWQI (Table 1). This is of particular importance, as nonpoint source pollution represents the primary water quality problem in Iowa.

The IWQI ranks each parameter differently from the NSFWQI in a way that takes into account geographic variability and adequately rates the risk of each parameter to Iowa's waters. Geographically dependent subindex rating curves for total suspended and total dissolved solids were developed for the IWQI to account for geologic and climatologic differences in the state that influence their concentrations. By defining geographic differences in baseline conditions of these parameters, the index does a better job of distinguishing baseline conditions from impaired conditions, which yields a more accurate assessment of water quality.

The IWQI subindex rating curves also do a better job of rating the water quality risk of each parameter. Subindex rating curves for key parameters that influence nutrient enrichment (such as phosphorus, biological oxygen demand, and dissolved oxygen) are adequately rated for their risk by having stricter rating curves than are used by the NSFWQI. The mathematical averaging function used by the IWQI is also better at rating all levels of water quality than is the function used in the NSFWQI, where the function tends to overestimate the quality of areas with poor water quality by masking low subindex scores in the presence of high subindex scores (Table 1).

Extensive statistical analysis found the IWQI to be superior to the NSFWQI at rating three different datasets with known conditions of water quality: worst water quality, best water quality, and average water quality. In all categories, the IWQI rated each dataset more accurately than did the NSFWQI. Reasons for the superiority of the IWQI in rating Iowa's water quality can be attributed to the fact that the IWQI includes parameters of concern to Iowa's water quality, adequately rates the risks of these parameters, and averages these risks using an equation that gives high statistical value to the lowest subindex value while still considering the influence of all other parameters.

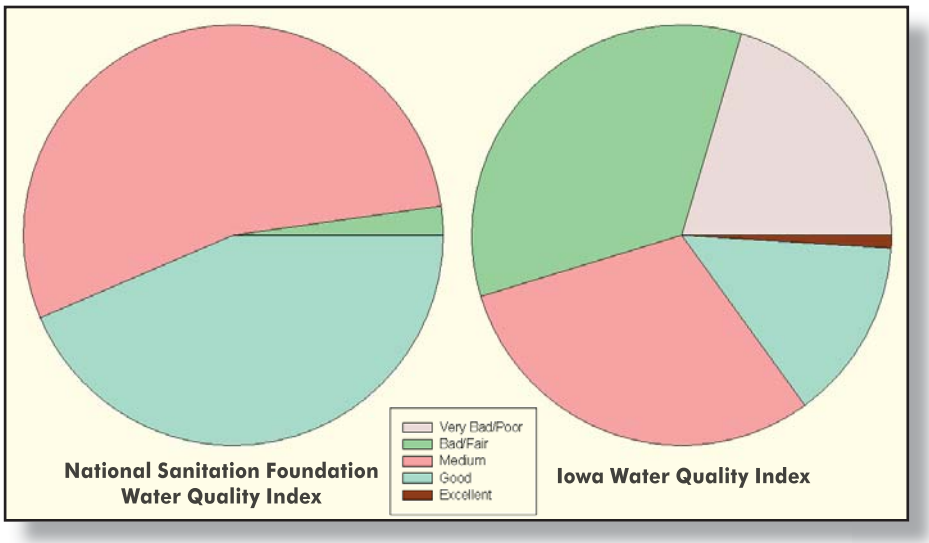


Figure 3. *National Sanitation Foundation Water Quality Index and Iowa Water Quality Index results from data collected as part of Iowa's Ambient Water Quality Program from 2000-2004. Pie charts depict the percentage of data in each category.*

Why is the IWQI Important?

Results from five years of Iowa's Ambient Water Monitoring Program show that the NSFWQI rates almost all of Iowa's waters as medium and good whereas the IWQI rates Iowa's waters with varying degrees of quality, ranging from very bad to excellent (Figure 3). The variability in IWQI results reflects a more accurate assessment of Iowa's waters using an improved index. This adequate representation of Iowa's waters allows for a better comparison of water quality conditions in different locations and therefore better prioritization of resources to the geographic areas in most need. The IWQI can be used to determine the extent to which existing water quality standards are being met and can also improve future water resources regulations. A water quality index that is specific to Iowa is invaluable in determining the spatial and temporal changes in water quality and in quantifying the effectiveness of Iowa's water quality regulations and protection programs.

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Iowa Watershed Monitoring and Assessment Program Web Site – wqm.igsb.uiowa.edu

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