# Integrating Water Monitoring Data:

## Water Quality Indices, Report Cards and Multi-metric Web Portals

Water monitoring programs often generate significant quantities of data for numerous chemical, physical and biological parameters and various media, such as water column, sediment and biota. Integrating these extensive and diverse data sets into information that is meaningful for use in water resource management and for dissemination to the public is often a challenge. The National Water Quality Monitoring Council, in partnership with New Jersey DEP, solicited information from water monitoring practitioners that are using different methods of communicating integrated water quality information for various types of water resources. Information on these various methods and examples of water quality indices, report cards and multi-metric portals are provided below. Each approach can provide a way to tell an effective story about water quality.

## Water Quality Indices (WQI)

A water quality index is a single value (score) used to summarize water quality and resource condition for a particular location and time period. Water quality indices are typically composed of several parameters (typically 4-12) of importance to water quality and are then aggregated and calculated into an overall score. Some of the most common parameters used in water quality indices are dissolved oxygen, pH, chlorophyll a, total nitrogen and total phosphorus.

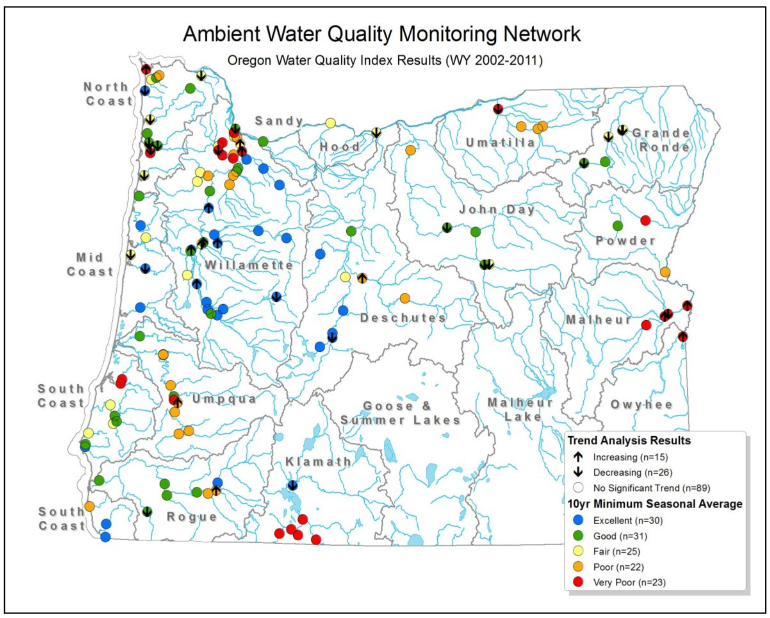


**Figure 1.** Example of spatial display of Oregon's WQI and trends results. Merrick, L. and S. Hubler, 2013. Oregon Water Quality Index Summary Report, Water Years 2002-2011 and 2003-2012.

| Strengths | Limitations |
|---|---|
| Summarizes large amounts of data for a variety of audiences | May not align with state's 305 (b)/303(d) Integrated Report assessments |
| Can be designed to complement the 305(b)/303 (d) Integrated Report | Generally not used for specific regulatory purposes, though it may inform regulatory decisions |
| May include information for parameters for which there are no regulatory standards | Many do not include toxics, habitat, fish tissue or biological indices |
| Enables spatial display of ratings | Single parameters of importance may lose significance in composite index |
| Enables trends analyses of WQI scores | |
| Generally understood by public, however, calculation of index may be confusing | |

**Figure 2:** Summarizes the strengths and limitations of Water Quality Indices

**What you need to know**

A WQI is commonly used to communicate overall water quality conditions to the public, stakeholders, local officials, and water resource managers, and also to track progress of management practices and strategic goals. Most WQI's are not used for regulatory purposes in part because many parameters often included have no water quality standards. However, a WQI may be used to provide background information to a contemplated regulatory action.

**How are water quality indices calculated, and what, if any, criteria/ standards or thresholds are utilized in the index determination?**

There are several approaches that have been applied to developing a WQI. Methods for aggregating subindices/parameters into an overall cumulative index calculation include weighted means, unweighted harmonic square means, and averaging ranked subindices into an overall score. The National Sanitation Foundation WQI uses a weighted mean, whereas the Oregon WQI uses an unweighted harmonic square mean formula which gives the most impaired variable more influence in the final WQI score. The Canadian Water Quality Index uses the measures of three factors (scope, frequency and amplitude) and their deviations from standard criteria. When standards exist they are generally applied; however, when no standards exist, published findings or thresholds derived from non-regulatory guidelines or percentiles of historical data are commonly used to set breakpoints among rating categories (e.g. good, fair, poor). The South Carolina Estuarine and Coastal Assessment Program uses water quality standards, published literature, and thresholds derived from percentiles of historical data (Bergquist et al., 2009). Many WQI's are developed by agency scientists or academics with input from a panel of experts, and peer reviewed internally or published in a peer reviewed journal.

Biological indices can be incorporated into the composite WQI, as many states have regionally developed multi-metric indices for fish, benthic macroinvertebrates or periphyton. The South Carolina Estuarine and Coastal Assessment Program uses their benthic index combined with their sediment quality index, and water quality index to provide a composite overall habitat quality index.

# Integrating Water Monitoring Data:
## Water Quality Report Cards

**About**

The Water Quality Report Card concept described here was originally developed by Warren Kimball, formerly of the Massachusetts Department of Environmental Protection, and is becoming a popular model used by water resource agencies. The WQRC uses ten indicators pertaining to aquatic life, recreation, and fish edibility that are color coded to provide an assessment of a waterbody based on the standardized 305(b)/303(d) reporting procedures. The ten indicators used by Kimball are biology, chemistry, nutrients, toxics, sediments, flow, habitat, bacteria, aesthetics, and fish tissue.

### What are the primary uses of the WQRC and who are the primary audiences?

The WQRC is used to communicate overall water quality conditions to the public, stakeholders, local officials and water resource managers. The WQRC condenses multiple assessment endpoints into a one page summary of a water resource. It can be used to express Clean Water Act assessment outcomes, evaluate the effectiveness of management practices, guide decision makers, identify monitoring needs and coordinate monitoring programs. Many WQRC are used by citizen scientist and watershed organizations to describe the conditions of their watershed.

*Millers River* — WATER QUALITY REPORT CARD — *2000 Assessment*

COLOR KEY: GOOD, CONCERN, FAIR, POOR, N/A

| | AQUATIC LIFE | | | | | | | RECREATION | | FISH EDIBILITY |
|---|---|---|---|---|---|---|---|---|---|---|
| SEGMENT | BIOLOGY | CHEMISTRY | NUTRIENTS | TOXICS | SEDIMENTS | FLOW | HABITAT | BACTERIA | AESTHETICS | FISH TISSUE |
| MILLERS RIVER | | | | | | | | | | |
| to Whitney pond | F | | | | | Q | | | | Hg |
| to Winchendon WWTF | | pH | | U | | Q | | B | C | Hg,PCB |
| to Otter River | | pH | P | U | | Q | | | | Hg, PCB |
| to South Royalston | | | P | | PCB | | | | | Hg,PCB |
| to Orange Center | A,F | pH | P | | PCB | Q | | | | Hg, PCB |
| to Erving WWTF | A,F | pH | P | | PCB | Q | | | | Hg, PCB |
| to Connecticut River | | pH | P | U | PCB | Q | | | C | Hg, PCB |
| OTTER RIVER | | | | | | | | | | |
| to Gardner WWTF | I,F | DO,pH,T | P | | | | | | C | Hg, PCB |
| to Seaman Paper Co. | I,F | DO,pH, T | P | U | Me | Q | S | | C,D | Hg, PCB |
| to Millers River | I,F | pH | P | | PCB | Q | | | O,C,D | Hg, PCB |
| TULLY RIVER | | | | | | | | | | |
| East Branch | F | pH | | | | | S | | G | Hg, PCB |
| Boyce Brook | | pH | | | | | | | | Hg, PCB |
| West Branch | | | | | | | | | | Hg, PCB |
| Lawrence Brook | | pH | | | | | | | | Hg,PCB |
| Main Stem | F | | | | | | | | | Hg, PCB |
| | | | | | | | | | | |
| | | | | | | | | | | |

**Figure 3.** Example of Massachusetts Department of Environmental Protection's Water Quality Report Card for a watershed illustrating use of colors to assess water quality for each indicator and letters to indicate specific parameters. Source: Warren Kimball. (PowerPoint from webinar available at http://acwi.gov/monitoring/webinars/index.html, "10/10/2012: "SMART" Monitoring: Strategic Monitoring and Assessment for River Basin Teams")

| Strengths | Limitations |
|---|---|
| Summarizes large amounts of water quality data | No overall rating category (e.g. good, fair, poor) of waterbody or segment |
| Can be designed to complement the 305(b)/303(d) Integrated Report | Lack of spatial display of rating |
| Can be developed using agency or organization-specific criteria or assessment methods ( e.g. watershed association report cards) | Limited trends analyses |
| Identifies monitoring gaps (gray areas in Figure 3) | |
| May include nutrients, toxics, habitat, fish tissue and biological assessments | |
| May identify reasons for impairment ( e.g. Hg, PCB for fish tissue in Figure 3) | |
| Generally understood by public | |

### How are the indicators for each column assessed, and what, if any, criteria/standards or thresholds are utilized in the determination?

The indicators may be assessed using the 305(b)/303(d) reporting rules and methodologies as described by the state or agency. For example, the "Biology" indicator may use the state's or locally valid benthic index of biotic integrity score to rate (good, fair, poor, etc.) each stream segment in the report card. For parameters which may not have numerical criteria, best professional judgement or percentile ranges based on historical data can be used to assign a category (good, fair, poor, etc.) to an indicator.

# Integrating Water Monitoring Data:

## Multi-Metric Web Portals

### About

There are additional ways to bring information from multiple perspectives together to tell a story about water quality. For example, the California Water Quality Monitoring Council has formed a number of theme-specific workgroups, each charged with developing a web portal devoted to a particular theme, based on uses of water that are to be protected. Each portal addresses a key management question with data and assessment information from relevant state, federal, and local agency monitoring efforts. All are accessible through a single My Water Quality website, [www.MyWaterQuality.ca.gov](http://www.MyWaterQuality.ca.gov)

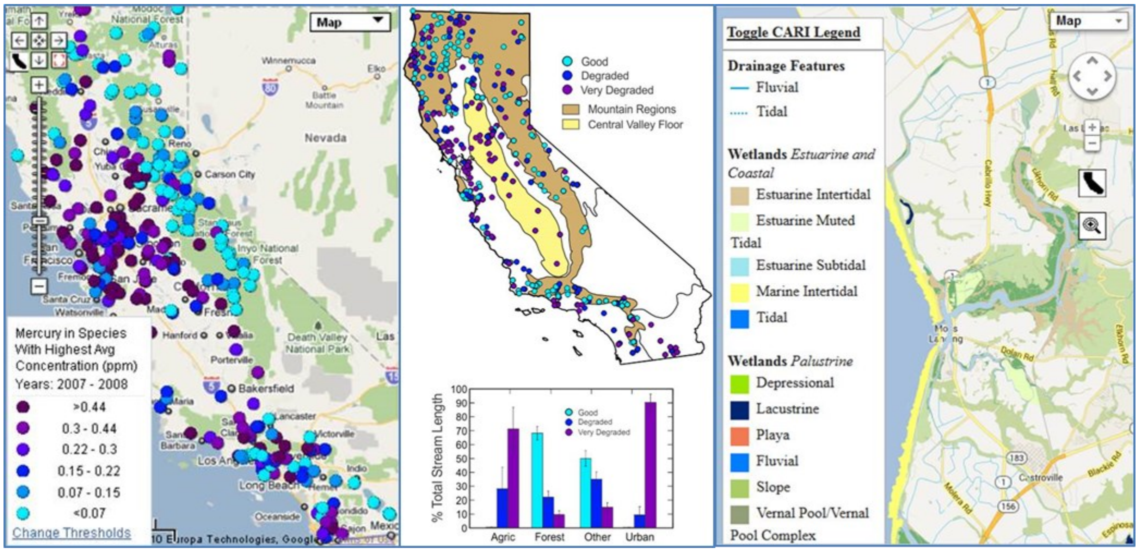


**Figure 4.** Examples of the various information, spatial display and data available from California Water Quality Monitoring Council web portal.

Another multi-metric web portal is the Vermont Integrated Watershed Information System (IWIS), a new online data portal that allows flexible and comprehensive access to many types of water quality information on lakes and streams in Vermont. These include chemical, physical and biological data available in several formats from site summaries to detailed individual measurements. The system allows multiple avenues from which to access data including a mapping interface on the Vermont Agency of Natural Resources Atlas as well as a form-based query tool. All retrieved data can then be downloaded in any number of formats such as Excel or PDF.

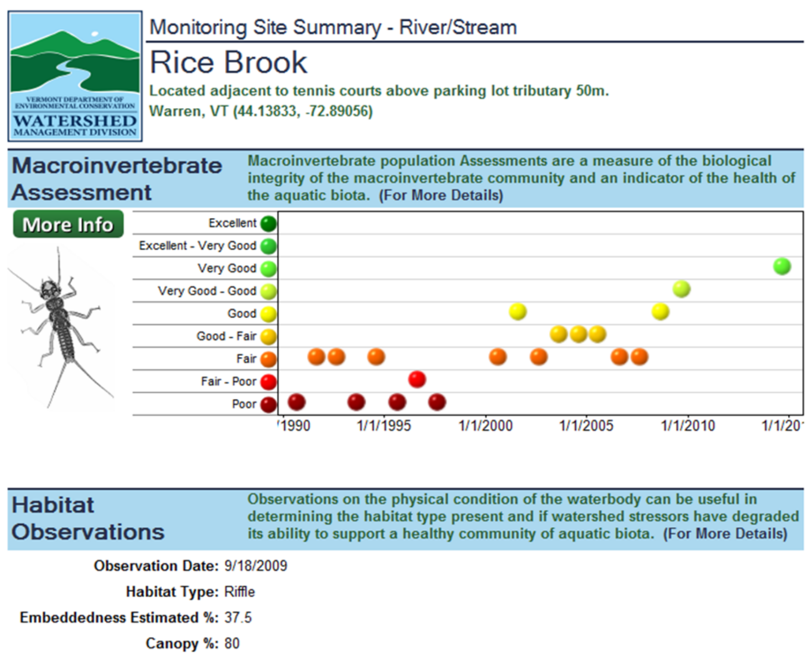


**Figure 5.** Example of a monitoring site summary available from the Vermont Integrated Watershed Information System (IWIS).

### What are the primary audiences for multi-metric web portals?

Portals can be designed to address multiple audiences, including agency decision-makers, legislators, permit writers, researchers, and the public. Higher level pages normally target less-sophisticated users, but allow others to drill down to more detailed information or to download relevant data.

| Strengths | Limitations |
|---|---|
| Deliver information to decision-makers, public and researchers that directly addresses their questions | Information is not always readily accessible in an electronic format that can be easily published on the web |
| Data and assessment information can be drawn from multiple agency monitoring programs, allowing broader assessments to be made through information sharing | Multi-metric indices that present overall water quality picture may not be included |
| Building a portal can bring together subject matter experts from various programs or state, federal, and local agencies, developing long-term relationships that can improve monitoring efficiency | For multiple program/organization portals, various perspectives presented need to be carefully explained to avoid confusing audiences |
| Underscore important work of various programs and organizations involved, increasing transparency and building credibility | Require agreement by the organizations involved as to how the data and information are presented; an overall management structure, such as a state monitoring council, can help address consensus |

# Examples of Water Quality Indices, Report Cards and Multi-Metric Web Portals

| Organization | Water Resource | Media | Website |
|---|---|---|---|
| **Water Quality Indices** | | | |
| Canadian Council of Ministers for the Environment | Rivers and streams | Water column | http://ceqg-rcqe.ccme.ca/download/en/137 |
| Iowa Department of Natural Resources | Rivers and streams | Water column | http://www.iowadnr.gov/Environment/WaterQuality/WaterMonitoring/WQI.aspx |
| Kentucky Department of Environmental Protection | Rivers and streams | Water column, sediment | http://water.ky.gov/waterquality/Pages/TMDLHealthReports.aspx |
| McMaster University | Great Lakes coastal marshes | Water column | http://greatlakeswetlands.ca/wp-content/uploads/2011/07/Chow-Fraser-2006.pdf |
| Oregon Department of Environmental Quality | Rivers (4th and 5th order) | Water column | http://www.deq.state.or.us/lab/wqm/wqimain.htm |
| South Carolina Estuarine and Coastal Assessment Program (SCECAP) | Coastal tidal rivers and bays | Water column, sediment, biology | http://www.dnr.sc.gov/marine/scecap/ |
| United States Environmental Protection Agency (National Coastal Condition Assessment) | Estuaries | Water column, sediment, biology, habitat | http://water.epa.gov/type/oceb/assessmonitor/ncca.cfm |
| University of Maryland Center for Environmental Sciences-Integration and Application Network | Estuaries, coastal bays | Water column, biology | http://ian.umces.edu/ |
| Vermont Department of Environmental Conservation | Lakes | Water column, biology, habitat | http://www.watershedmanagement.vt.gov/lakes/htm/lp_lakescorecard.htm |
| **Water Quality Report Cards** | | | |
| State of California, San Diego Regional Water Quality Control Board | Rivers and streams | Water column, sediment, biology, habitat | http://www.waterboards.ca.gov/sandiego/water_issues/programs/swamp/index.shtml |
| Massachusetts Department of Environmental Protection | Rivers and streams | Water column, sediment, biology, habitat | http://acwi.gov/monitoring/webinars/index.html |
| **Multi-Metric Web Portals** | | | |
| State of California, Central Coast Regional Water Quality Control Board | Rivers and streams | Water column, sediment, biology, habitat | http://www.mywaterquality.ca.gov/monitoring_council/healthy_streams/docs/healthywatersheds_krw.pdf |
| State of California, Water Quality Monitoring Council | Rivers, streams, lakes, estuaries, wetlands, coastal ocean | Water column, sediment, biology, fish tissue | http://www.mywaterquality.ca.gov |
| Vermont Integrated Watershed Information System (IWIS) | Rivers, streams, lakes | Water column and biology | https://anrweb.vt.gov/DEC/IWIS/ |

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