Integrating water quality data with mainstream GIS

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Perspective

• Software engineering
• Consultant: civil / water resources support, “heavy industrial sector”
• Researcher/academia: SCM (BMPs)
• Whitewater kayaker: WQ “sampling”
• Land owner / stormwater enthusiast: building SCM (BMPs)
• Consultant for MDOT and MDTA: TMDL / CBay
  * proactive approach ☺
  * no clear direction, strategy ☹
What is current surface water quality?
Please wait while the features are configured. This might take several minutes.
WHAT IS CURRENT FLOW?

- Mobile site: [http://m.waterdata.usgs.gov](http://m.waterdata.usgs.gov)

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**Map Explanation**
- **High**
- **> 90th percentile**
- **76th - 90th percentile**
- **25th - 75th percentile**
- **10th - 24th percentile**
- **< 10th percentile**
- **Low**
- **Not ranked**
WHAT IS CURRENT FLOW?
(browsing session pre-recorded October 14, 2013)
What is current flow?
Map of real-time streamflow compared to historical streamflow for the day of the year (Pennsylvania)

Choose a data retrieval option and select a location on the map
- List of all stations
- Single station
- Nearest stations
- Peak flow

Explanation - Percentile classes

<table>
<thead>
<tr>
<th>Level</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Much below normal</td>
<td>10-24</td>
</tr>
<tr>
<td>Below normal</td>
<td>25-75</td>
</tr>
<tr>
<td>Normal</td>
<td>76-80</td>
</tr>
<tr>
<td>Above normal</td>
<td>&gt;90</td>
</tr>
<tr>
<td>Much above normal</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Notranked</td>
<td></td>
</tr>
</tbody>
</table>
Map of real-time streamflow compared to historical streamflow for the day of the year (Pennsylvania)

Monday, October 14, 2013 19:30ET
Map of real-time streamflow compared to historical streamflow for the day of the year (Pennsylvania)

Monday, October 14, 2013 19:30 ET

Additional Information:
- WaterAlert email and text message alerts
- Subscribe WaterAlert for this site

Choose a data retrieval option and select a location on the map
- List of all stations
- Single station
- Nearest stations
- Peak flow

Explanation - Percentile classes

- Low: Much below normal, Below normal, Normal
- High: Much above normal
- Not-ranked

USGS
What is current flow?

Flood Tracking Chart Builder

Site number: 01474500  Value type: Gage Height  Size: Normal (700x500)

01474500 Schuylkill River at Philadelphia, PA

Stage, feet

Current Stage 6.43 feet on 2013-10-14 18:00:00 (provisional)
Recent Maximum Stage (previous 365 days) 10.54 feet on 2013-01-31 (provisional)
Highest Recorded Peak Stages at Current Datum
National Weather Service Flood Stage 11 foot

Additional Information

- USGS real-time streamflow data
- USGS peak streamflow
Over 200 USGS real-time streamgages used to support NWS river forecasts and warnings are at risk of being discontinued. Click here for more information from the USGS...
Map of real-time streamflow compared to historical streamflow for the day of the year (Pennsylvania)

Monday, October 14, 2013 19:30ET

Additional Information:
- Explanation
- Shift-adjusted rating table

Choose a data retrieval option and select a location on the map
- List of all stations
- Single station
- Nearest stations
- Peak flow

Explanation - Percentile classes

<table>
<thead>
<tr>
<th>Low</th>
<th>10-24</th>
<th>25-75</th>
<th>75-90</th>
<th>&gt;90</th>
<th>High</th>
<th>Not-ranked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Much below normal</td>
<td>Below normal</td>
<td>Normal</td>
<td>Above normal</td>
<td>Much above normal</td>
<td>High</td>
<td>Not-ranked</td>
</tr>
</tbody>
</table>
Map of real-time streamflow compared to historical streamflow for the day of the year (United States)

Monday, October 14, 2013 18:30ET

Choose a data retrieval option and select a location on the map
- List of all stations in state,
- State map, or
- Nearest stations

<table>
<thead>
<tr>
<th>Explanation - Percentile classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
</tr>
<tr>
<td>&lt;10</td>
</tr>
</tbody>
</table>

USGS
HERE IS CURRENT FLOW

- Centralized Data
- Current and Historic
- Real-Time Analysis
- GIS-Integrated
- Graphic Presentation
WHAT IS CURRENT WQ?


Presentation only for temp, cond, pH, D.O., turb, and Nitrate

Real-Time Dissolved Oxygen, in mg/L

October 14, 2013 19:31ET

<table>
<thead>
<tr>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
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</tbody>
</table>

* Site operated on a seasonal basis or currently is not operating.
No values are available for the last 6 hours.

The “Real-time” map tracks short-term changes (over several hours) of water quality. Although the general appearance of the map changes very little from one hour to the next, individual sites may change rapidly in response to major rain events or to reservoir releases. The data used to produce this map are provisional.

Animate national map by current Month, or last 12 months
WHAT IS CURRENT WQ?
( browsing session pre-recorded October 15, 2013 )

Real-Time Water Temperature, in °C

October 15, 2013 21:30ET

The "Real-time" map tracks short-term changes (over several hours) of water quality. Although the general appearance of the map changes very little from one hour to the next, individual sites may change rapidly in response to major rain events or to reservoir releases. The data used to produce this map are provisional.

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SPECIFIC CONDUCTANCE
(browsing session pre-recorded October 15, 2013)
DISSOLVED OXYGEN
(browsing session pre-recorded October 15, 2013)

USGS 01474000 Wissahickon Creek at Mouth, Philadelphia, PA

Dissolved oxygen, water, unfiltered, milligrams per liter

----- Provisional Data Subject to Revision ----
pH
(browsing session pre-recorded October 15, 2013)
TURBIDITY
( browsing session pre-recorded October 15, 2013 )

--- Provisional Data Subject to Revision ---
DO
( browsing session pre-recorded October 15, 2013 )

USGS 01474000 Wissahickon Creek at Mouth, Philadelphia, PA

Dissolved oxygen, water, unfiltered, percent of saturation


---- Provisional Data Subject to Revision ----
Real-Time Nitrate, in mg/L

October 15, 2013 21:33ET

* Site operated on a seasonal basis or currently is not operating.
No values are available for the last 6 hours.
NITRATE

( browsing session pre-recorded October 15, 2013 )
NITRATE
(browsing session pre-recorded October 15, 2013)
CHLOROPHYLL
( browsing session pre-recorded October 15, 2013 )

Provisional Data Subject to Revision

Chlorophyll a, total, in situ fluorescence excitation at 370, 470, 525, 570, 610 nm, fluorescence emission at 700 nm with correction for CDOM, ug/L, from left intake

USGS 01389005 Passaic River below Pompton Riv at Two Bridges NJ

Concentrations less than or equal to 1 ug/L are highly variable
NITRATE: USA
(browsing session pre-recorded October 15, 2013)

Real-Time Nitrate, in mg/L

October 15, 2013 21:39 ET

USGS

* Site operated on a seasonal basis or currently is not operating.
  No values are available for the last 6 hours.

The "Real-time" map tracks short-term changes (over several hours) of water quality. Although the general appearance of the map changes very little from one hour to the next, individual sites may change rapidly in response to major rain events or to reservoir releases. The data used to produce this map are provisional.

Animate national map by current Month, or last 12 months
## SUMMARIES OF WATER POLLUTION REPORTING CATEGORIES

<table>
<thead>
<tr>
<th>Plain English Category Name</th>
<th>ATTAINS EPA Database Attribute Name</th>
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</thead>
<tbody>
<tr>
<td>ABNORMAL FLOW</td>
<td>FLOW ALTERATION(S)</td>
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<tr>
<td>ACIDITY</td>
<td>PH/ACIDITY/CAUSTIC CONDITIONS</td>
</tr>
<tr>
<td>AMMONIA</td>
<td>AMMONIA</td>
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<tr>
<td>BACTERIA AND OTHER MICROBES</td>
<td>PATHOGENS</td>
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<tr>
<td>BIOLOGICAL POISONS</td>
<td>B IOTOXINS</td>
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<tr>
<td>CAUSE UNKNOWN</td>
<td>CAUSE UNKNOWN</td>
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<tr>
<td>CHLORINE</td>
<td>CHLORINE</td>
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<tr>
<td>DEGRADED AQUATIC LIFE</td>
<td>CAUSE UNKNOWN - IMPAIRED BIOTA</td>
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<tr>
<td>DEGRADED HABITAT</td>
<td>HABITAT ALTERATIONS</td>
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<td>DIOXINS</td>
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<td>EXCESS ALGAE</td>
<td>ALGAL GROWTH</td>
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<td>EXCESS AQUATIC WEEDS</td>
<td>NOXIOUS AQUATIC PLANTS</td>
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<td>EXCESS SEDIMENT</td>
<td>SEDIMENT</td>
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<tr>
<td>FISH KILLS</td>
<td>CAUSE UNKNOWN - FISH KILLS</td>
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<tr>
<td>FISH UNSAFE TO EAT</td>
<td>FISH CONSUMPTION ADVISORY</td>
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<tr>
<td>LOW OXYGEN</td>
<td>ORGANIC ENRICHMENT/OXYGEN DEPLETION</td>
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<tr>
<td>MERCURY</td>
<td>MERCURY</td>
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<tr>
<td>METALS</td>
<td>METALS (OTHER THAN MERCURY)</td>
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<tr>
<td>MURKY WATER</td>
<td>TURBIDITY</td>
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<tr>
<td>NITROGEN AND PHOSPHORUS</td>
<td>NUTRIENTS</td>
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<td>NUISANCE PLANTS OR ANIMALS (FOREIGN)</td>
<td>NUISANCE EXOTIC SPECIES</td>
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<td>NUISANCE PLANTS OR ANIMALS (NATIVE)</td>
<td>NUISANCE NATIVE SPECIES</td>
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<td>OIL AND GREASE</td>
<td>OIL AND GREASE</td>
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<tr>
<td>PCBs</td>
<td>POLYCHLORINATED BIPHENYLS (PCBS)</td>
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<td>PESTICIDES</td>
<td>PESTICIDES</td>
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<tr>
<td>POLLUTED, OTHER CAUSE</td>
<td>OTHER CAUSE</td>
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<tr>
<td>RADIATION</td>
<td>RADIATION</td>
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<tr>
<td>SALTS</td>
<td>SALINITY/TOTAL DISSOLVED SOLIDS/CHLORIDES/SULFATES</td>
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<tr>
<td>TASTE, COLOR AND ODOR</td>
<td>TASTE, COLOR, AND ODOR</td>
</tr>
<tr>
<td>TEMPERATURE</td>
<td>TEMPERATURE</td>
</tr>
<tr>
<td>TOTAL TOXIC CHEMICALS</td>
<td>TOTAL TOXICS</td>
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<tr>
<td>TOXIC INORGANIC CHEMICALS</td>
<td>TOXIC INORGANICS</td>
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<tr>
<td>TOXIC ORGANIC CHEMICALS</td>
<td>TOXIC ORGANICS</td>
</tr>
<tr>
<td>TRASH</td>
<td>TRASH</td>
</tr>
</tbody>
</table>

What is current WQ?

Additional USGS DATA

• USGS NWIS:
  vast amounts of data, mostly in tabular format

• Example: Site No. 01474080 Schuylkill River bl Rt. 30 near Philadelphia, PA
What is current WQ?
State-level: PADEP, including TMDL
What is current WQ?
State-level: CADEP, including TMDL

CADEP TMDL:

CADEP: MY WQ (IS IT SAFE TO SWIM / DRINK / EAT FISH, ETC?)

- http://www.mywaterquality.ca.gov/safe_to_swim/
- http://www.mywaterquality.ca.gov/safe_to_eat/
What is current WQ?

“National Summary of Assessed Waters Report”
(e-version: ATTAINS database)

- USA: http://www.epa.gov/waters/ir/index.html
- PA: http://ofmpub.epa.gov/waters10/attains_state.control?p_state=PA
How to make sense of all this?
Issues left out:

- Designated use: impaired “industrial-use” stream?

- Is it possible to create isolated sterile environment? (e.g. “clean” Chesapeake Bay in the “dirty” ocean?)

- Exporting “pollution”?

- Feedback on the programs under CWA: cost-benefit? return on investment? Efficiency / effectiveness? How many raingardens (e.g. VU Traffic-Island type) needed to clean CBay?

- SCMs life cycle: where to put “hot” soil?

- Big picture: What is the source of pollution? It is not SW, not Atm. D. – it is our cars, our ag, industrial facilities, our power plants. It “comes with the territory”.
TO SEE BIG[GER] PICTURE:
Integrated framework

• Help with assessment of remaining areas
• Help making sense of the data
• Help with feedback from current “tools”
• Public engagement
• Prevention
• ???????
Feedback: tools ↔ effects

- Tools of choice: SCMs (BMPs) efficiency? cost-benefit?
- Monitoring?
- “Low hanging fruit” - $$$?
- Geo-specificity?
- Improvement time frame?
- Improve to what level?
- Longevity / life cycle of tools?
Integrated framework

- WQ data: current and historic
- WQ assessment (pass / fail, details)
- Pollutant sources
- Tools (SCMs, BMPs, etc.) inventory
- Tools library / toolbox
- Feedback: correlate SCMs to WQ
- Tools requirements
- New tools, R & D
Module 1: WQ assessment

- Assessment / monitoring
- Consolidate data
- Standardize criteria, incl. designated use, world-wide
- Standardize reporting (e.g: CO$_2$ equivalent, APGAR score)

http://brc.healthebay.org/
Module 2: WQ threats

- “Point-source”
- “Non-point source”

* At what point the “point source” becomes “non-point source”?
Module 3: WQ improvement tools

- BMPs?
- SCMs?
- Existing inventory
- Required inventory
- Prioritized lists
- Monitoring / feedback
Module 4: crowd sourcing

• Citizen-scientists (verified / vetted): employ “citizen science” approach

• Ex: NASA – astronomy; genom sequences; Wikipedia; face / voice recognition; Open source software: Firefox, Unix, Android, Apache, etc.

• Incentives
Module 5: R & D

• More effective SCMs?
• More effective ways at “fighting” point-source (NPDES)?
• More effective ways at “fighting” Non-PS? Identifying Non-PS?
• Incentives
Getting there: obstacles

• Technology (e.g: is WQ sampling not advanced enough?)
• Data disintegration?
• Sensitivity of the data?
• Corporations / lobbying?
• Etc...
Technical Challenges

• Enormous amount of data
• Consolidating sources / hosting in one place?
• Use distributed data model, use daily “crawler” to recognize and consolidate?
• How reliable is the data?
EarthMD by

- NICE
- HMMM...
- CALL ER!
Acknowledgements

• Dr. Andrea Welker

• Villanova University
  Stormwater Partnership

• William Penn Foundation