Combined Sewer Overflows

Combined sewer systems were designed to collect rainwater runoff, domestic sewage, and industrial waste in the same pipe. During periods of rainfall, the wastewater volume in a combined system can exceed the capacity of the system or the treatment plant. When this capacity is exceeded, the excess wastewater flows directly into nearby streams and rivers. This typically occurs during heavy or extended rain events but can happen as a result of very little rain. These overflows can contain not only stormwater but also untreated human sewage, industrial waste, toxic materials, and other debris. This small watershed study focuses on stormwater and the impacts of CSOs on water quality during high flow events.

As of June 2010, more than 130 CSOs are still active and can discharge into the Lackawanna River and its tributaries between Carbondale and Old Forge, Pa., during rain events. In addition, surface stormwater flows over land, across un-vegetated mine spoil piles and contributes to excessive particulate sedimentation and further degraded water quality (LRCA, 2001).

Combined sewer overflow systems have been a priority of federal and state water quality regulators for the past 20 years. In 1994, USEPA published a national framework for the control of CSOs, which, in 2000, was incorporated into the Wet Weather Water Quality Act. In 2008, PADEP Bureau of Water Standards and Facility Regulation published the Pennsylvania Combined Sewer Overflow Policy.

CSOs continue to be a concern in many older cities, including the greater Scranton area, because of the considerable resources and time needed to completely rework an area's wastewater infrastructure. However, a substantial amount of money has been invested already in the Lackawanna River Watershed to fix the problems related to CSOs. For example, over the past ten years, the Lackawanna River Basin Sewer Authority (LRBSA) has completed numerous projects at the Throop wastewater treatment plant in Dickson City. These improvements include automatic mechanical screening to remove solids and debris, additional chlorine disinfection to reduce fecal coliform, eliminating one CSO discharge by rerouting the flow back to the treatment plant, and installing a remote monitoring system to alert facilities of possible overflows. Other improvements within the LRBSA include standby emergency generators to maintain operation in the event of power loss, a wet weather treatment system, updated interceptors, and manhole improvements. Additionally, for local citizens concerned about stormwater, LRCA has information about rain gardens, downspout disconnection, and rain barrels on its web site (www.lrca.org).

Methods

Between July 2009 and March 2010, SRBC staff collected base flow and stormflow water quality samples at 15 locations within the Lackawanna River Watershed. Macroinvertebrate samples also were collected at four locations in July 2009. Table 1 contains a list of station names, sampling location descriptions, drainage areas, and latitude and longitude coordinates for each of these sites. Given the number of CSOs in the watershed (more than 130), it is not feasible to sample at all of them during

Table 2. Water Quality Standards and Levels of Concern and References

Parameter	Limit	Reference
Temperature	> 25 degrees	a,e
Dissolved Oxygen	< 4 mg/l	a,f
Conductivity	> 800 μmhos/cm	c
pH	< 5	b,e
Total Suspended Solids	> 15 mg/l	g
Total Dissolved Solids	>500 mg/l	a,h,i
Total Organic Carbon	> 10 mg/l	j
Total Nitrogen	> 1.0 mg/l	h
Total Phosphorus	> 0.1 mg/l	d, k
Total Copper	> 200 ug/l	i
Total Iron	>1.5 mg/l	a
Total Lead	>65 ug/l	n
Total Zinc	>120 ug/l	n
Total Aluminum	0.75 mg/l	a.
Total Cadmium	>5 ug/l	i
Total Chromium	>100 ug/l	n

Reference Code & References

a. http://www.pacode.com/secure/data/025/chapter93/s93.7.html
b. Gagen and Sharpe (1987) and Baker and Schofield (1982)
c. http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm
d. http://www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm
e. http://www.hach.com/h2ou/h2wtrqual.htm
f. http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/pondstream.pdf
g. http://www.epa.gov/waterscience/criteria/sediment/appendix3.pdf
h. http://water.usgs.gov/pubs/circ/circ1225/images/table.html
i. http://www.dec.state.ny.us/website/regs/part703.html
j. Hem (1970) – http://water.usgs.gov/pubs/wsp/wsp2254/
k. http://water.usgs.gov/nawqa/circ-1136/h6.html#NIT
l. http://www.epa.gov/waterscience/criteria/wqcriteria.html
m. EPA (2002), EPA 822-R-02-038
n. http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/wqstandards/index.asp

a storm event. Sampling sites were selected so SRBC staff could collect water quality data upstream and downstream of major urban areas and bracket as many clusters of CSOs as possible. The farthest upstream site was chosen to be a reference site, as it was located in a mainly forested area and north of the greater Scranton metro area.

Base flow samples were collected instream, when possible, for field and laboratory water quality parameters and stream discharge. Water was collected using a hand-held, depth integrated sampler at six verticals across the stream channel. At locations where stream entry was not possible, a depth-integrated bridge sampler was used. The water was composited into a churn splitter and mixed thoroughly before filling sample bottles for laboratory analysis. Table 2 lists the parameters analyzed in this study, which included nutrients, metals, and other pollutants. The remaining water was used to measure field chemistry parameters: water temperature, pH, dissolved oxygen, conductivity, and turbidity. Stream discharge was measured using a FlowTracker according to U.S. Geological Survey (USGS) methods (Buchanan and Somers, 1969).

These water quality parameters were chosen to incorporate the constituents expected to be found in stormwater runoff and CSO discharges. These included nutrients, indicators of organic pollution, and metals. Also listed are the references for the water quality standards and levels of concern that were used for analysis.

Macroinvertebrates were surveyed to provide a biological assessment of the aquatic habitat conditions in the watershed. Macroinvertebrates were collected at a subset of the sites using a modified version of Rapid Bioassessment Protocol (RBP) III (Barbour and others, 1999). Two kicks were done using a one-meter kick screen net in the best available riffle habitat. All material collected was composited into one sample and preserved in the field with 90 percent ethanol for later lab processing and identification. Since only four macroinvertebrate samples were collected, results were compared to reference sites of a similar drainage size as determined by the Middle Susquehanna Subbasin Survey, which was completed in 2008 (Buda, 2009). Table 3 gives an explanation of the metrics used to evaluate the macroinvertebrate data. An assessment of physical habitat also was completed for all sampling locations where macroinvertebrates were collected.

SRBC Aquatic Biologist collecting a water sample.

Table 3. Explanation of Macroinvertebrate Metrics

TAXONOMIC RICHNESS: Total number of taxa in the sample. Number decreases with increasing stress.

HILSENHOFF BIOTIC INDEX: A measure of organic pollution tolerance. Index value increases with increasing stress.

PERCENT EPHEMEROPTERA: Percentage of number of Ephemeroptera in the sample divided by the total number of macroinvertebrates in the sample. Percentage decreases with increasing stress.

PERCENT CONTRIBUTION OF DOMINANT TAXA: Percentage of the taxon with the largest number of individuals out of the total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

EPHEMEROPTERA, PLECOPTERA, TRICHOPTERA INDEX (EPT INDEX): Total number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa present in a sample. Number decreases with increasing stress.

PERCENT CHIRONOMIDAE: Percentage of number of Chironomidae individuals out of total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

SHANNON-WIENER DIVERSITY INDEX: A measure of the taxonomic diversity of the community. Index value decreases with increasing stress.

Storm samples were collected during December 2009 and March 2010. When possible, staff collected two samples at each site during the duration of the rain event with the goal of obtaining one sample on the rise and one sample as close to peak flow as possible. Samples were collected from bridges during storm events, and the water was processed in the same manner as described above for the base flow samples. Instantaneous flow data from three USGS gages on the Lackawanna River were used to determine flows and estimate when samples should be taken at each sampling location.

In addition to base flow and storm sampling, staff also deployed YSI water quality sondes on numerous occasions to gather continuous water chemistry data over a one- or two-week period that included a rain event. These instruments are designed to be deployed in the river on a long-term (weeks to months) basis and collect data at set intervals over that time frame. These sondes were calibrated in the laboratory prior to deployment and were set to collect data every 15 minutes for pH, dissolved oxygen, conductance, temperature, and turbidity.