

Watershed Assessment: Pollutant Sources

What is pollution?

General pollution definition: “the presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects” (Merriam Webster Dictionary)

Water pollution definition: “...man-made or man-induced alteration of chemical, physical, biological, and radiological integrity of water” (Clean Water Act, 1987)

Pollution is a change in the physical, chemical, radiological, or biological quality of a resource (air, land, or water) caused by man or due to man's activities that is injurious to existing, intended, or potential uses of the resource.



Why is it important to understand pollutants and control their contamination?

Cuyahoga River Fire

One of the most polluted rivers in the US caught fire on June 22, 1969

Catalyst event for the introduction of the Clean Water Act in 1972



The New York Times

E.P.A. Vows Better Effort on Water

By CHARLES DUHIGG

Published: October 15, 2009



Judy Treml said her daughter Samantha, 5, was sickened as an infant when farm runoff polluted their well in Wisconsin.

“The agency has not settled on a list of potential targets, but is likely to focus on mining companies, large livestock farms, municipal wastewater treatment plants and construction companies that operate sites where polluted stormwater has run into nearby lakes and rivers.”

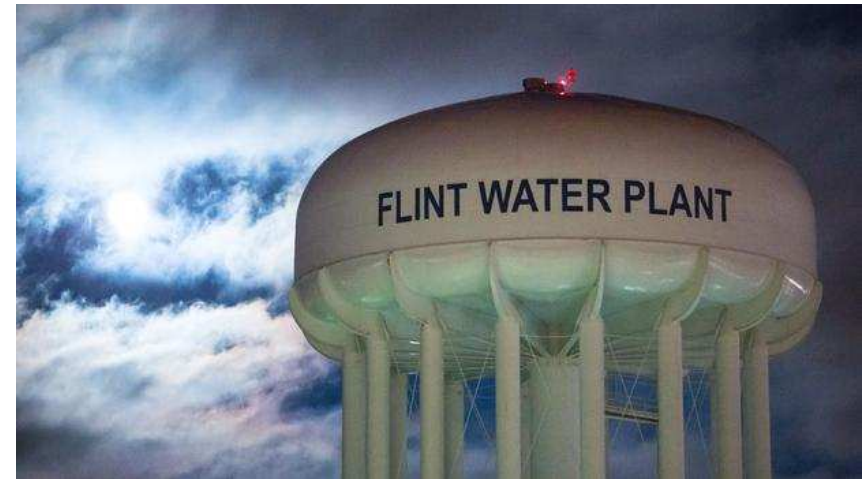
http://www.nytimes.com/2009/10/16/business/energy-environment/16water.html?_r=1&ref=earth

Most recently: Flint Water Crisis

Drinking water in Flint, Michigan contaminated with elevated concentrations of lead, which is a serious public health danger

Can be extremely harmful and debilitating towards children and impact their cognitive function permanently

Legal process is ongoing



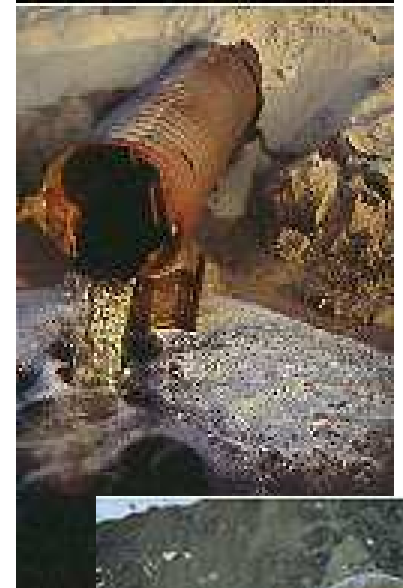
Types of Pollution

- Point sources
- Non-point sources



Point sources of pollution

“...any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged. This term does not include agricultural stormwater and return flows from irrigated agriculture.” (Water Quality Act 1987).



Point sources of pollution



- Municipal and industrial wastewater effluent;
- Runoff and leachate from solid waste disposal sites;
- Runoff and percolation from concentrated animal feeding operations (CAFOs);
- Runoff from industrial sites not connected to storm sewers;
- Storm sewer outfalls in urban centers with populations >100,000;
- Combined sewer overflows;
- Runoff and drainage from active mines (surface and subsurface) and oil fields;
- Other sources such as discharges from vessels, damaged storage tanks, and storage piles of chemicals;
- Runoff from construction sites larger than 2 ha.

Point sources of pollution

Primary contaminants of interest:

- Degradable organics (Measured as BOD5 and COD)
- pH
- Suspended solids
- Nitrogen
- Phosphorus
- Toxic compounds
- Temperature

Non-point sources of pollution

- Sometimes referred to as *diffuse* pollution
 - Includes sources that are diffuse in nature and which are not discharged from a few localized points as described above. Essentially any pollution source that is not a statutory point source of pollution

EPA refers to non-point source pollution as any source of water pollution that does not meet the legal definition of “point source” in section 502(14) of the Clean Water Act.



Non-point sources of pollution



- Return flow from irrigated agriculture;
- Agricultural and silvacultural runoff and percolation from sources other than large AFOs;
- Runoff and percolation from pasture and rangeland;
- Urban stormwater runoff from sewered communities with populations <100,000 not causing significant water quality problems;
- Urban stormwater runoff from unsewered areas;
- Runoff from small construction sites (<2ha);
- Septic tanks (surface runoff and percolation from);
- Wet and dry deposition over surface water;
- Runoff and percolation from abandoned mines (surface and subsurface), including inactive roads, tailings, and spoil piles;

Non-point sources of pollution

- Land disturbing activities, including:
 - Deforestation and logging
 - Wetland drainage and conversion;
 - Stream channelization, dam building, levee construction, flow-diversion facilities, etc. on navigable waters;
 - Land development and construction;
 - Interurban transportation;
 - Military activities;
 - Mass outdoor recreation.



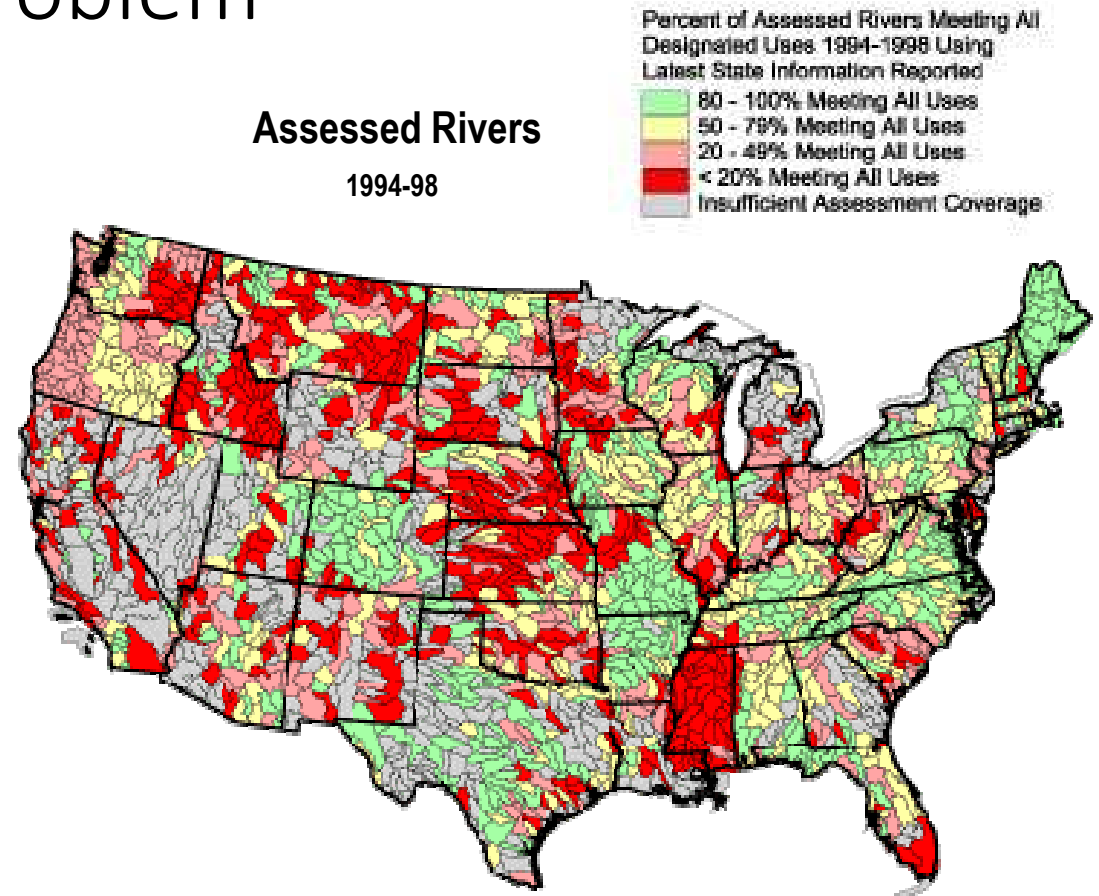
Compare and contrast point and non-point source pollution. How does this impact watershed planning and assessment?

Point vs. non-point source

- Point Source Pollution – in general is continuous in nature with minimal variability or correlation to meteorological factors.
 - Controlled through treatment
- NPS Pollution – highly variable in time and strongly correlated with meteorological factors, primarily precipitation.
 - Controlled through pollution prevention rather than treatment.

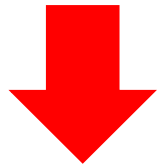
Magnitude of the problem

- As of 1998, EPA reports:
 - 40% of U.S. streams, rivers, lakes, and estuaries not clean enough for basic use
 - Agriculture responsible for 60% of NPS



Magnitude of the problem: Kansas

State of Kansas listed more than 1000 water bodies requiring TMDLs in 1998



Today there are 1,264 impaired waters in Kansas (2016)

Impaired Waters and TMDLs in Region 7

Serving Iowa, Kansas, Missouri, Nebraska and Nine Tribal Nations.
Region 7's water priority is protecting and improving water quality across America's greatest watershed, the Missouri-Mississippi Basin.



<https://www.epa.gov/tmdl/impaired-waters-and-tmdls-region-7>

Total Maximum Daily Load (TMDL)

What is a TMDL?

<https://www.epa.gov/tmdl>

TMDL: the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant

The screenshot shows the EPA website page for TMDLs. At the top is the EPA logo and navigation tabs for 'Learn the Issues', 'Science & Technology', 'Laws & Regulations', and 'About EPA'. A search bar is on the right. The main heading is 'Implementing Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs)'. Below this is a banner image of a lake with a text overlay: 'Identifying Polluted Waters and Developing Plans to Restore Them'. To the right of the banner is a green box with the text: 'Final Rule - Treatment of Indian Tribes in a Similar Manner as States for Purposes of Section 303(d) of the Clean Water Act'. Below the banner is a paragraph of text explaining TMDLs. On the right side, there are three boxes: 'Upcoming Events' with a link to 'Modeling Webinar', 'What's New in the 303(d) Program', and 'Water Regulation in the U.S.'.

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Identifying Polluted Waters and Developing Plans to Restore Them

- Final Rule - Treatment of Indian Tribes in a Similar Manner as States for Purposes of Section 303(d) of the Clean Water Act

A TMDL is a pollution budget and includes a calculation of the maximum amount of a pollutant that can occur in a waterbody and allocates the necessary reductions to one or more pollutant sources. A TMDL serves as a planning tool and potential starting point for restoration or protection activities with the ultimate goal of attaining or maintaining water quality standards. Under section 303(d) of the Clean Water Act, states, territories and authorized tribes (included in the term State here) are required to submit lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet water quality standards. The law requires that the states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDL) for these waters.

Lists of impaired waters and TMDLs are reviewed in EPA's regional offices.

Upcoming Events

- Modeling Webinar

What's New in the 303(d) Program

Water Regulation in the U.S.

Region 7 Cumulative TMDLs by Pollutant

This chart includes TMDLs since October 1, 1995.

[Description of this table](#)

NOTE: Click on the underlined "Pollutant Group" value to see a detailed list of pollutants. Click on the underlined "Number of TMDLs" value to see a listing of those TMDLs for the pollutant Group.

<u>Pollutant Group</u>	<u>Number of TMDLs</u>	<u>Number of Causes of Impairment Addressed</u>
Salinity/Total Dissolved Solids/Chlorides/Sulfates	968	973
Pathogens	804	847
Organic Enrichment/Oxygen Depletion	538	555
Metals (other than Mercury)	535	542
Nutrients	427	452
Turbidity	170	184
Sediment	131	139
Pesticides	129	135
pH/Acidity/Caustic Conditions	90	91
Toxic Inorganics	82	82
Algal Growth	51	56
Cause Unknown - Impaired Biota	32	32
Ammonia	23	24
Other Cause	14	15
Noxious Aquatic Plants	11	12
Polychlorinated Biphenyls (PCBs)	7	7
Mercury	5	6
Temperature	5	5
Chlorine	4	4
Cause Unknown	2	2
Toxic Organics	1	1

Total: 4,029 TMDLs; 4,164 Causes of Impairment Addressed

Region 7 Probable Sources Contributing to Impairments

[Description of this table](#)

<u>Probable Source Group</u>	Size of Assessed Waters with Probable Sources of Impairments		
	<u>Rivers and Streams (Miles)</u>	<u>Lakes, Reservoirs, and Ponds (Acres)</u>	<u>Wetlands (Acres)</u>
<u>Agriculture</u>	1,330	53,499	4,153
<u>Atmospheric Deposition</u>	740	28,350	
<u>Construction</u>		172	
<u>Habitat Alterations (Not Directly Related To Hydromodification)</u>	489		
<u>Hydromodification</u>	1,615	60,499	4,416
<u>Industrial</u>	564		140
<u>Land Application/Waste Sites/Tanks</u>	4	370	
<u>Legacy/Historical Pollutants</u>	26		
<u>Municipal Discharges/Sewage</u>	1,144	41,747	
<u>Natural/Wildlife</u>	427	47,032	5,620
<u>Other</u>	34	430	237
<u>Recreation And Tourism (Non-Boating)</u>	62		
<u>Resource Extraction</u>	264		
<u>Spills/Dumping</u>	320		
<u>Unknown</u>	6,667	70,028	3,479
<u>Unspecified Nonpoint Source</u>	2,315	44,720	
<u>Urban-Related Runoff/Stormwater</u>	256	540	

NOTE: Click on a source of impairment (e.g. agriculture) to see the specific state-reported sources that are grouped to make up this category.

Rural NPS pollution

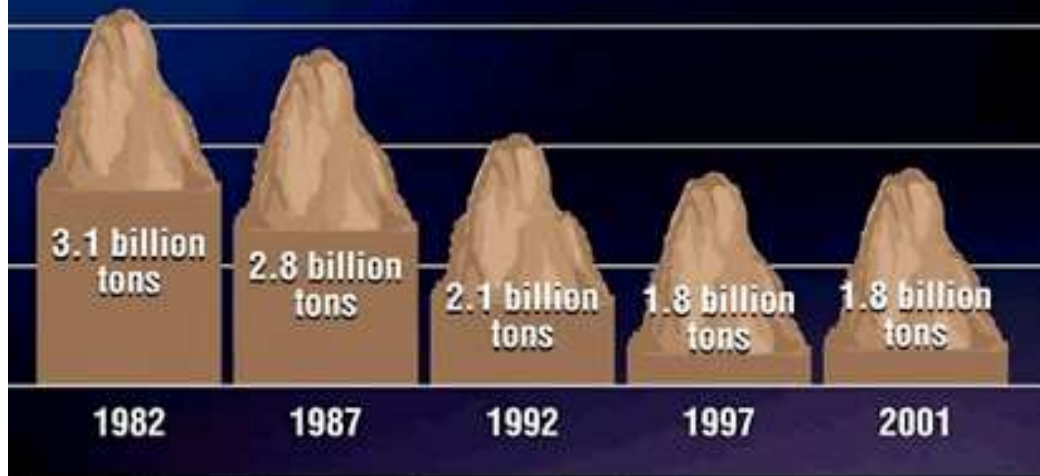
What are the major issues of concern?

Rural NPS pollutants of concern

SEDIMENT : 4 billion tons/year with approximately half due to natural geologic erosion and the rest resulting from human activities (predominantly agriculture)



Total Soil Eroded on U.S. Cropland (1982 to 2001)



Source: Natural Resources Conservation Service

AKA approximately 40,000,000 train cars filled with soil!



Rural NPS pollutants of concern

NUTRIENTS (agriculture)

- Nitrogen: 6.8 million tons/year
- Phosphorus: 2.6 million tons/year



Rural NPS pollutants of concern

PATHOGENS

- If measured with total coliform, approximately 98% are from non-point source pollution
 - Point sources are not very significant because sewage treatment plants disinfect discharges
 - NPS's, septic tanks, and animal production facilities, do not.



Rural NPS pollutants of concern

PESTICIDES

- Problems generally due to misuse. Only 2 to 3% of pesticides reach target organism. Modern pesticides are not persistent like earlier chlorinated hydrocarbons (DDT, Dieldrin, Diazanine, etc.).



Urban NPS pollution

Are urban NPS sources different from rural?

Urban NPS pollution

In cities with secondary treatment, stormwater runoff accounts for 40 to 80% of the annual BOD loading and most of the sediment, nutrient, and bacterial loadings to streams. Urban runoff is also the principal NPS of heavy metals, toxic organics, petroleum products, and organic solvents.



Atmospheric deposition

- Varies greatly from area to area depending on local air quality, pollutant sources, and how recently the air was “scrubbed” by precipitation
- Nutrients are occasionally sufficient to cause eutrophic aquatic plant growth
 - Estimated that approximately 25% of the nitrogen loading to the Chesapeake Bay is due to atmospheric deposition
 - The Clean Air Act is reducing some atmospheric deposition



Three phase equilibrium

- Solid Phase
 - Precipitated
 - Strongly sorbed
- Liquid phase
 - Dissociated in water
- Gas phase
 - Volatilized



Contaminant equilibrium

Total Contaminant = liquid + solid + gas

$$C_T = \theta C_e + rM + ac_g$$

Where:

θ = volumetric water content

C_e = concentration in the dissolved phase (ug/L)

r = concentration in the solid phase (ug/g)

M = mass of soil per volume (g/L)

a = volumetric air content

c_g = vapor density of the chemical (ug/L)

Other pollutant transformations

- Biological degradation and transformation
 - Monod's equation
 - Michaelis-Menten equation
- Chemical oxidation-reduction
- Hydrolysis
- Photochemical

Factors affecting pollutant transformation:

- pH
- Temperature
- Water Content
- Organic Carbon
- Clay Content
- Oxygen
- Nutrients
- Microbial Population
- Chemical Concentration

