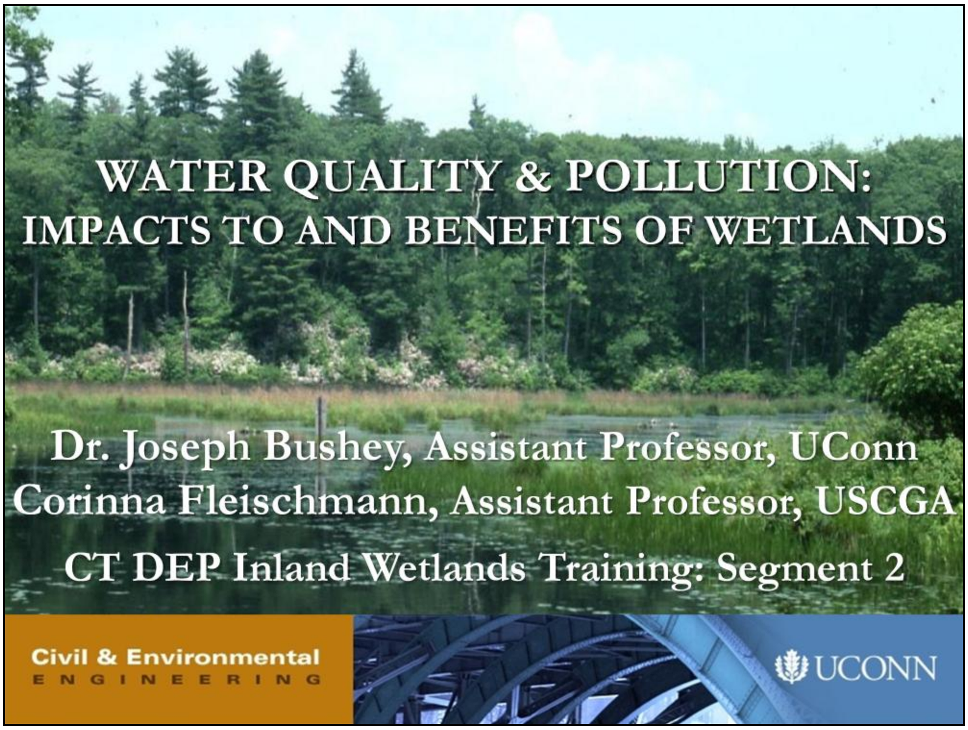

Contact information: www.engr.uconn.edu/cee

We will begin with an overall examination of what is "pollution," discuss some primary water quality issues.

Then, we will move on to some typical impacts that IWC will deal with and address the effectiveness and cost of mitigation measures.

Straw poll used to generate discussion on what WAS the state of the environment … then jump to how this has changed.

London – early 1850s

cholera epidemic surrounding Broad Street Pump

Dr. John Snow – broke handle to pump "breaking" the case

Pre-1908: filtration used to purify drinking water

Boonton Reservoir (NJ) – 1st system in US chlorinated 1908

Safe Drinking Water Act

Killer smog – Donora, PA

atmospheric inversion layer trapped pollutants near surface in a valley near Pittsburgh, PA – killing several people

led to increased atmospheric awareness of air pollution

Cuyahoga River (Cleveland) caught fire!!! Yes, water CAN burn! Resulted from garbage and oil on surface

Not the only incident involving harbors burning

Love Canal, NY – near Buffalo

Toxic dumping site in old canal

"bathtub" eventually filled with water and seeped into french drains and neighborhood –

exposing residents to VERY high levels of pollutants

Increased cancer and disease

Led to CERCLA (a.k.a. "Superfund") in 1980

Fish kill due to low oxygen in water – likely but not necessarily

CSS outfall in West Hartford – YES!

-note garbage and toilet paper in reeds in foreground

Stormwater filled with sediment – YES!

Acid mine drainage (low pH – acid – and high metals) – YES!

-orange color is sign of iron oxide (think rust) formation as water equilibrates with air

How healthy ***is*** the environment?

5. Very healthy
4. Healthy
3. Fair
2. Unhealthy
1. Very unhealthy

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Minimized ACUTE TOXICITY resulting from human impacts

Challenges posed by current environmental problems:

- •Subtle
- •Complex
- •Global (Transboundary)
- •Multi-generational(Chronic)

Algae growing on pond – MAYBE?

•Eutrophication is a natural process of elevated nutrients which has been dramatically accelerated in many cases due to human inputs

Crandall Pond (Tolland) – high bacterial counts during summer following rain events – YES!

Aberjona River, Woburn MA – MAYBE?

•River is a Superfund site with multiple contaminants, including organics (remember the movie *A Civil Action*)

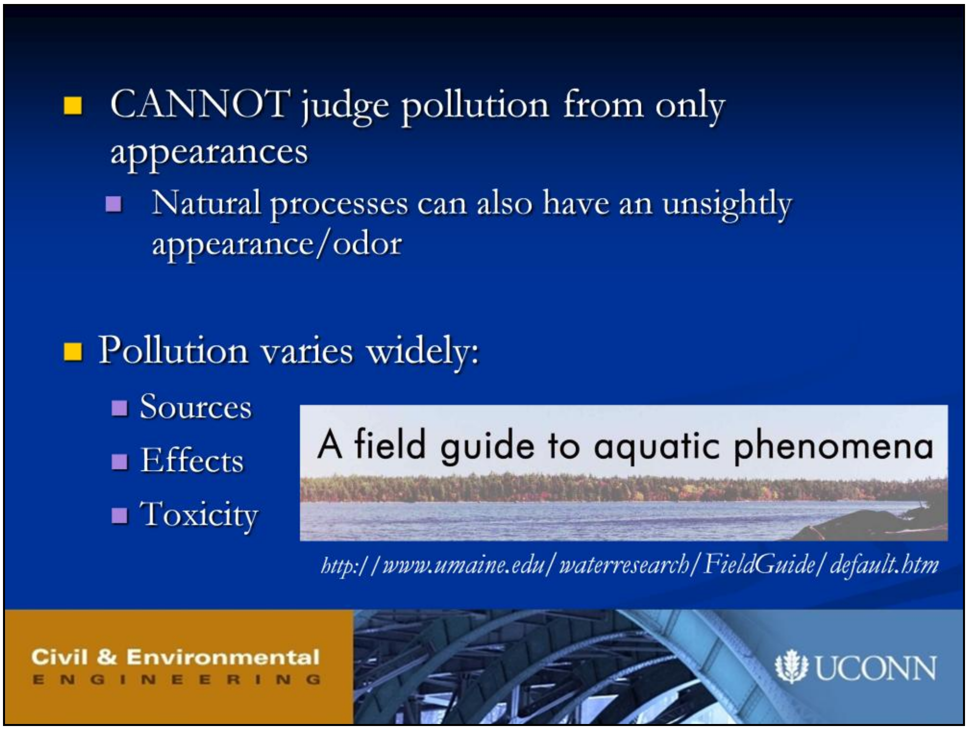
•BUT, organic sheen on surface can also develop naturally from biological action in water body where chemicals are released into water

Sunday Pond, NY – in the heart of the Adirondack Mountains

•About 3 miles from nearest house

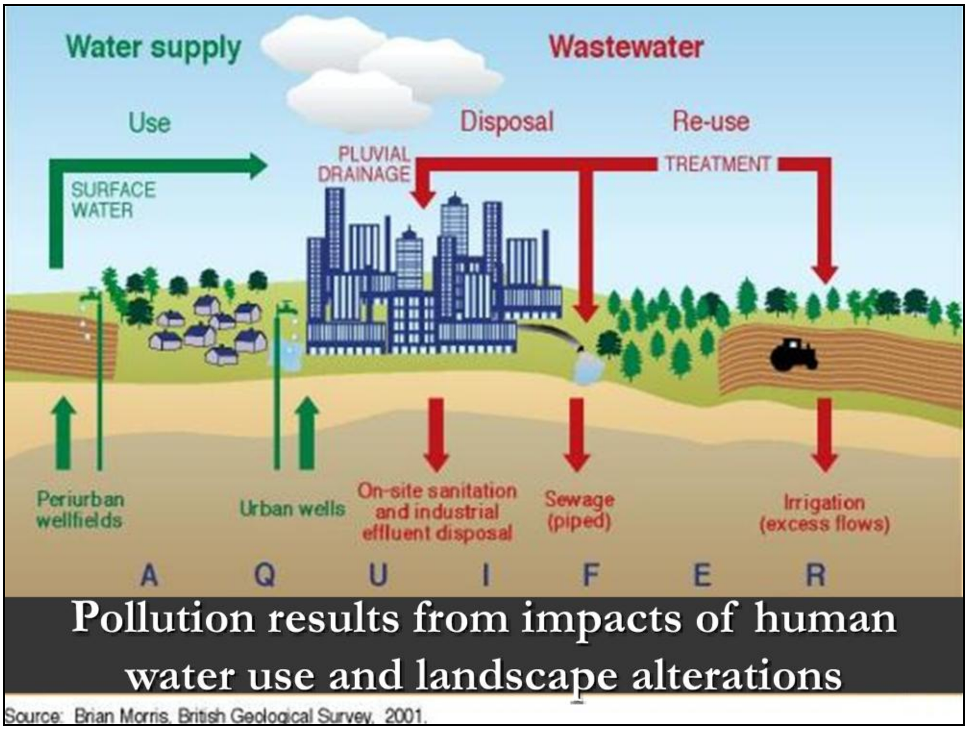
•Foam results from DOC released into water from wetlands upstream

•Natural process – NO!

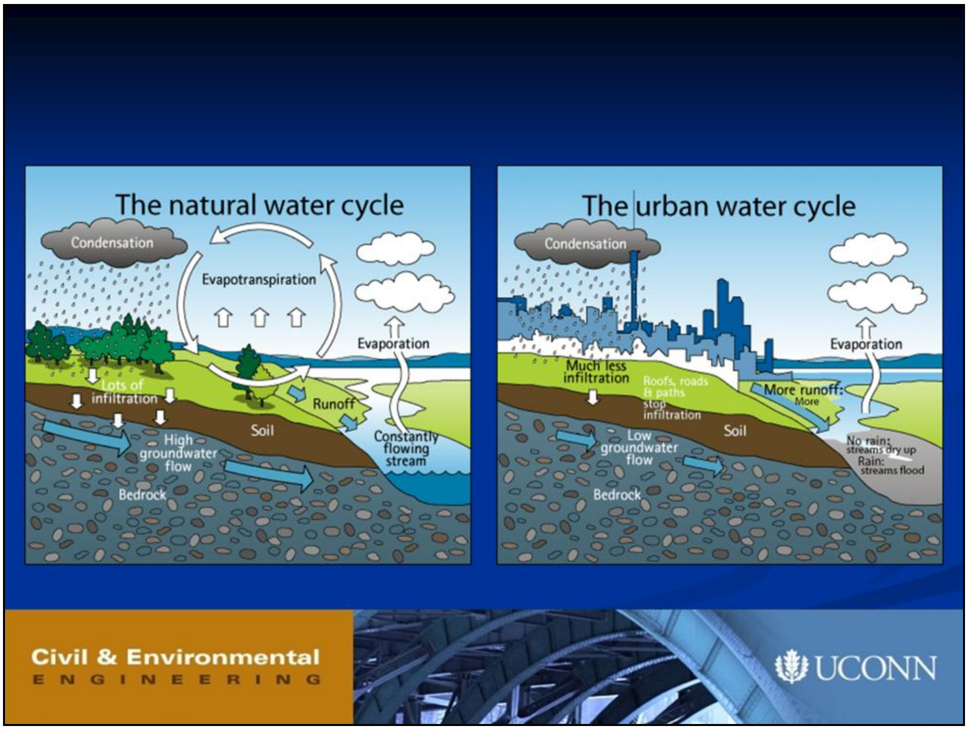


Sometimes it is difficult to determine what is or is not an impacted water body only true method is through measurement

The website gives a great overview of some natural appearances often mistaken for pollution



Humans have altered the water cycle, particularly in urban settings. Water is pulled from rivers and aquifers (groundwater sources), used and then either directly deposited back into surface waterways or allowed to infiltrate back into the ground. Use adds contaminants to the water leading to impacts to surface and groundwater bodies. These impairments can make the water unsuitable for not only ecosystems and native biota, but also for future human use. The alteration of the water cycle also changes the water balance in many streams, limiting the amount available for "use" by the native biota.



Urbanization alters the hydrologic cycle by:

- increasing runoff
- decreasing infiltration
- lower evapotranspiration from plants
- lower groundwater flow

- Impacts
  - Physical – linked to hydrologic cycle and runoff
  - Chemical / Biological – pollution and associated alterations in chemical cycling
  - Ecological – changes in habitat

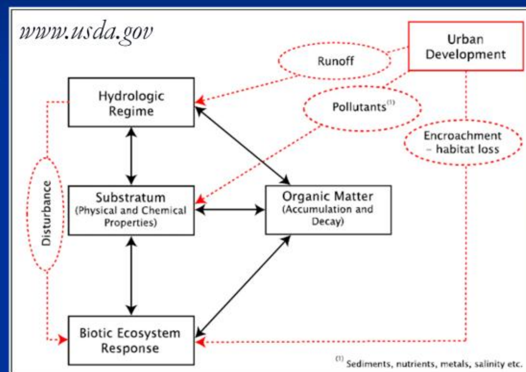


Figure 1 - Conceptual model of wetland function indicating potential threats from urban development to the natural function of wetlands (after Breen 1992)

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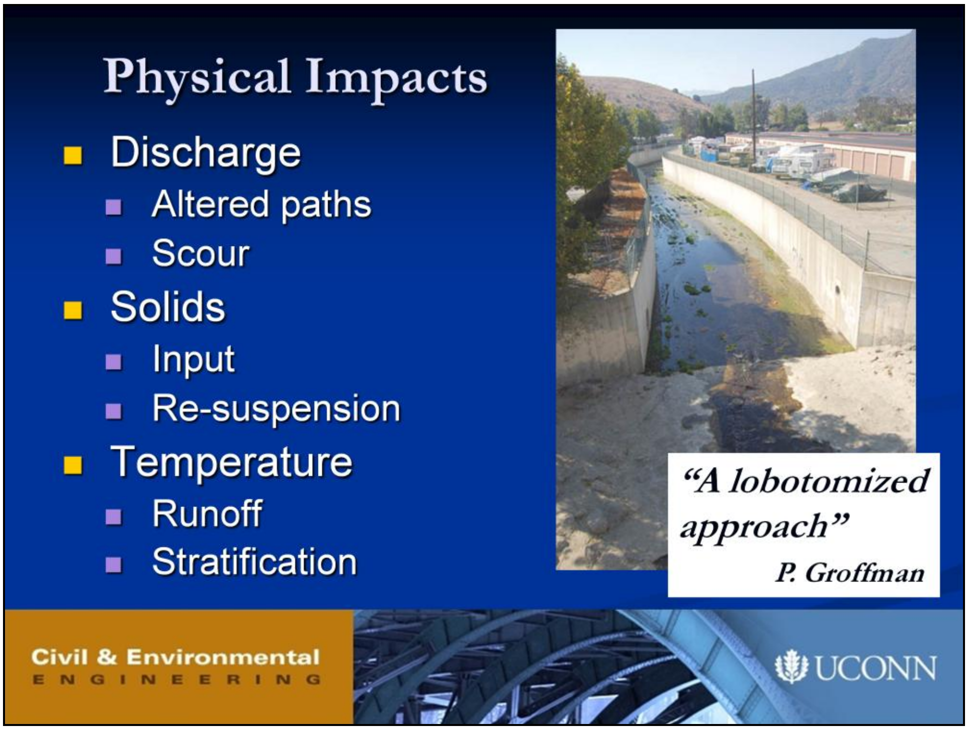
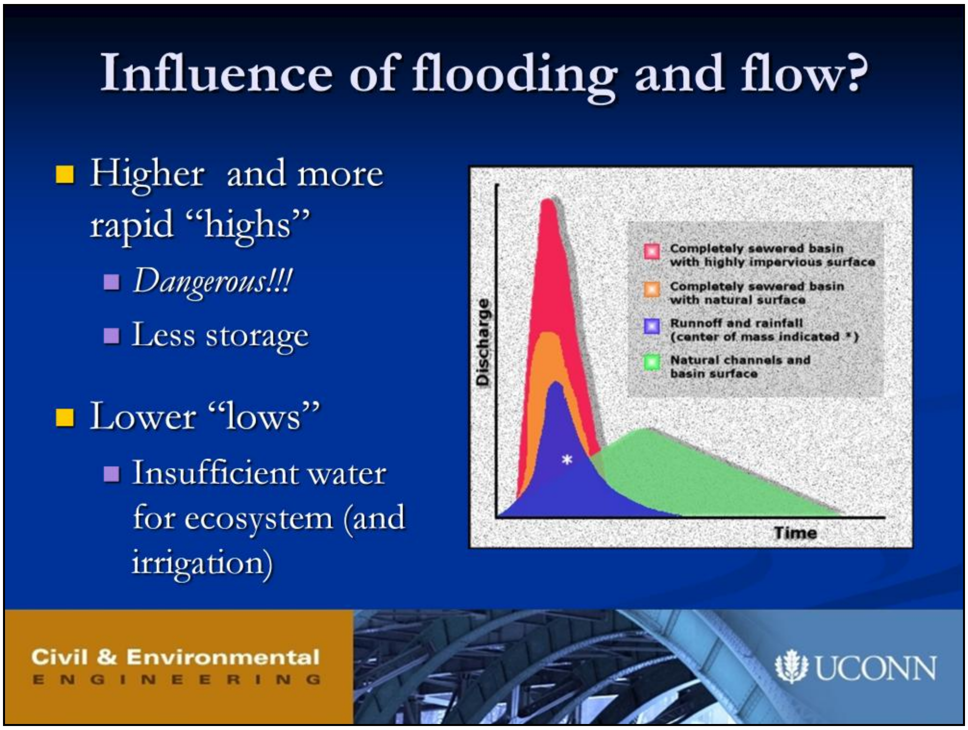
Human alterations lead to changes in Runoff, Pollutant loads, and Ecosystem connectivity. These can be summarize into three categories of impacts: physical, chemical/biological, and ecological. We will explore each of these further …



Many channelized urban streams are "lobotomized," meaning that much of the ecosystem processes and connections have been removed. Putting the streams in channels to control the direction of water cuts off the natural process of surface/groundwater interaction, removes streamside buffers and tree cover. Biotic action in the stream is decreased.

The physical impacts in many of these streams center on increases in discharge due to impervious surface runoff

- altered flow paths – gouges into the stream channel eroding banks
- scours any solids present
- receives higher runoff and soil eroded from impervious cover
- urban heat island increases the temperature due to lack of cover

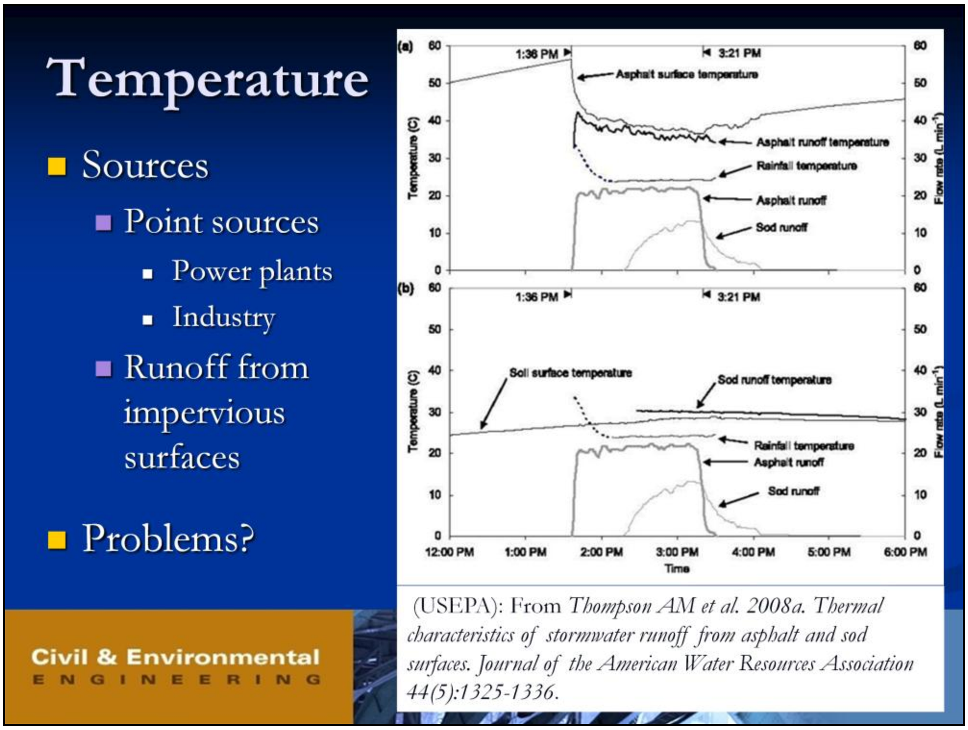


The peak and amount of runoff given by the green forested curve is lower and more spread out than that in the urbanized systems. As the urbanization increases (to blue, then orange, then red), note that the highest discharge value goes up significantly and that this occurs much faster! You’ll also note that the stream quickly comes back down to baseline as water is not stored in the watershed and released slowly to the stream after the rain event has passed. This leads to decreases dry period flows in urban streams.

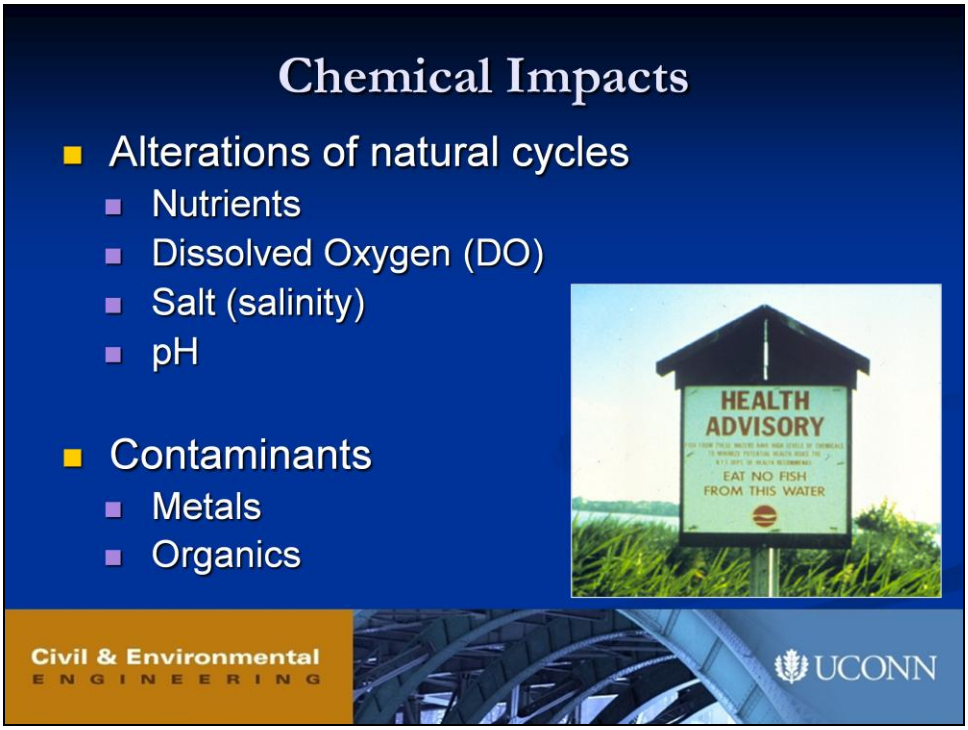
A fine example of scour in a stream site in the Baltimore, MD, long-term environmental research site. Note the large site of the cobbles present and the lack of vegetation. The bags on the side of the stream provide an example of the height to which the flow increases during runoff events!!! These are approximately 8 ft above the current water position!!! This was my “introduction” to stormflow in the urban setting – at first I was amazed at the amount of debris that the wind had blown into the trees. Boy was I mistaken – this is actually due to the water!!!

Solids can be contributed to the water from disturbed areas such as construction sites and agricultural lands. They also occur as stream bed sediments are scoured (re-suspended) into the flow.

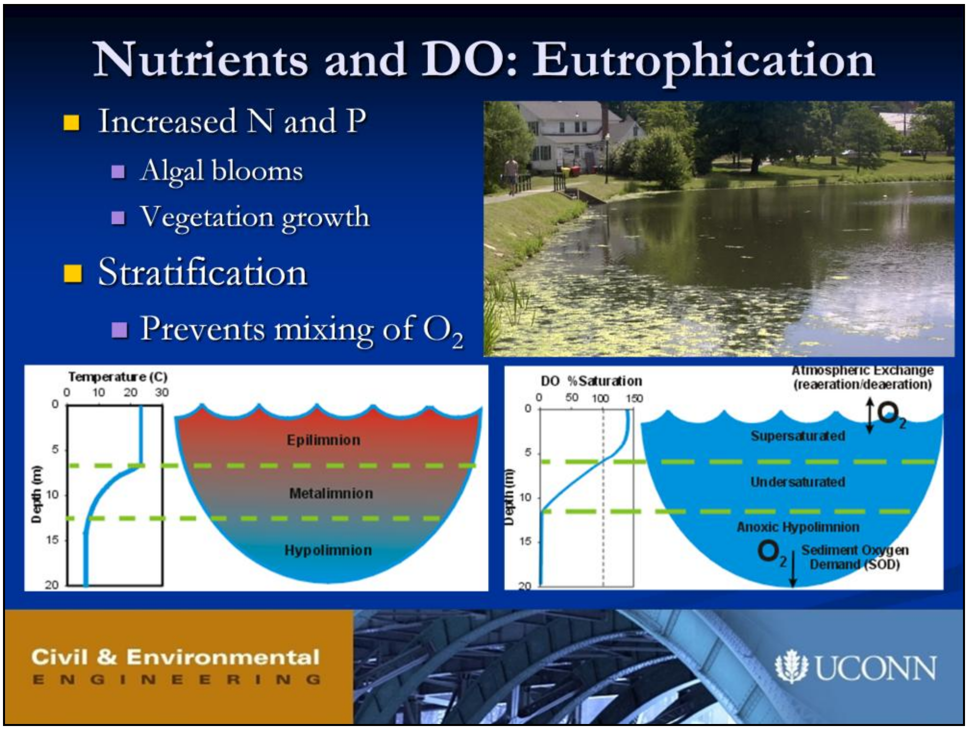
Why are solids bad? They block light and clog gills, leading to vegetation and animal deaths. Underwater plants need access to sunlight and also don’t like to be covered continually by new layers of sediment. For fish, this would be akin to walking downwind of a farmer plowing his field and breathing in all of the dust.



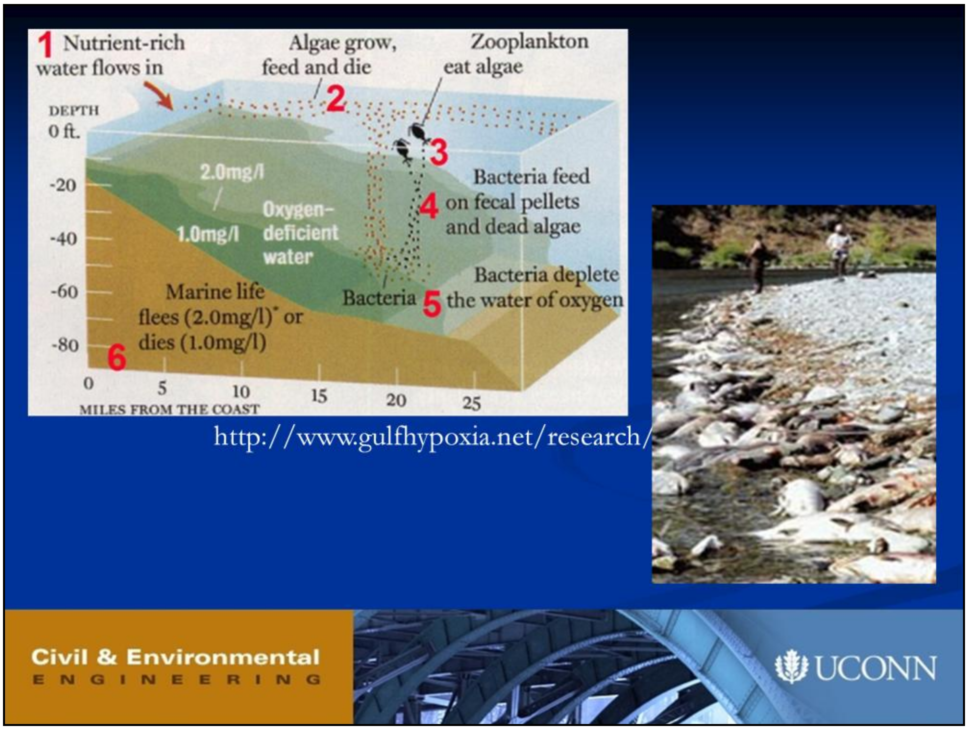
Paved surfaces heat up – think of walking on blacktop in bare feet. This heat is transferred to rainfall which runs off into streams at a higher temperature. Also, industrial process water tends to be heated – the majority of water use in the US is actually for cooling of power plants.



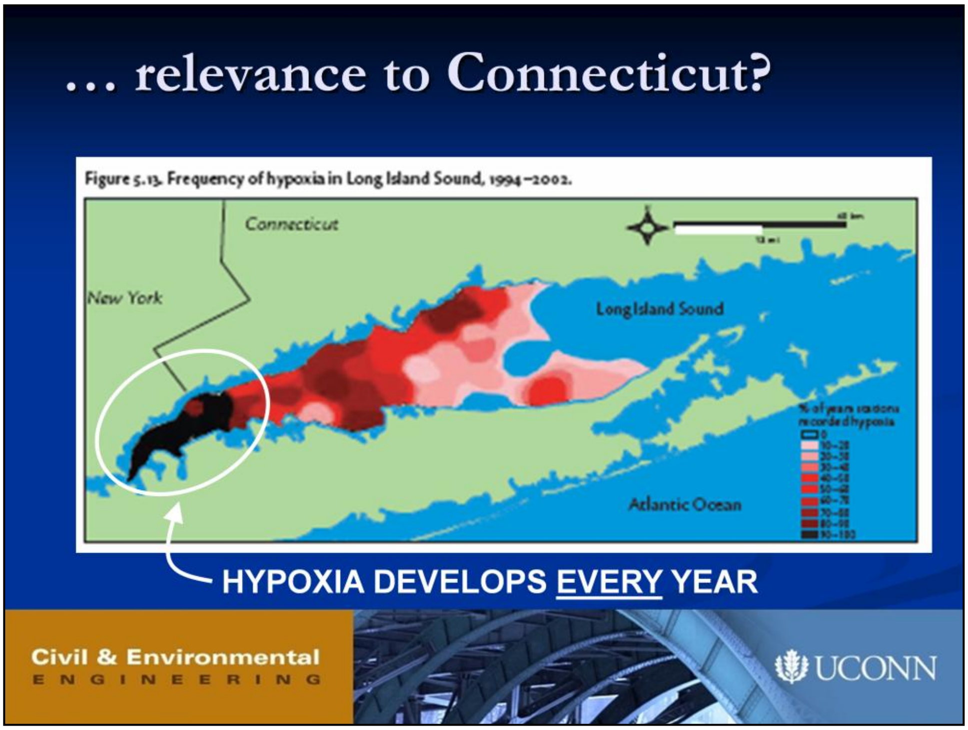
Chemical impacts can involve shifts in natural cycles or the addition of chemical not found in nature (i.e., “contaminants”). Many chemicals are required for growth, including N, C, P and many metals. However, human use has added these elements to water and increased their concentrations to deleterious levels. Additionally, humans use has sped up many natural processes.



This is a prime example of humans speeding up a natural cycle. Increased nutrients is only part of the process. The other component is stratification – or separation of a water body into multiple layers that do not mix. This layering can occur due to temperature and salinity and usually occurs in most lakes during late summer.



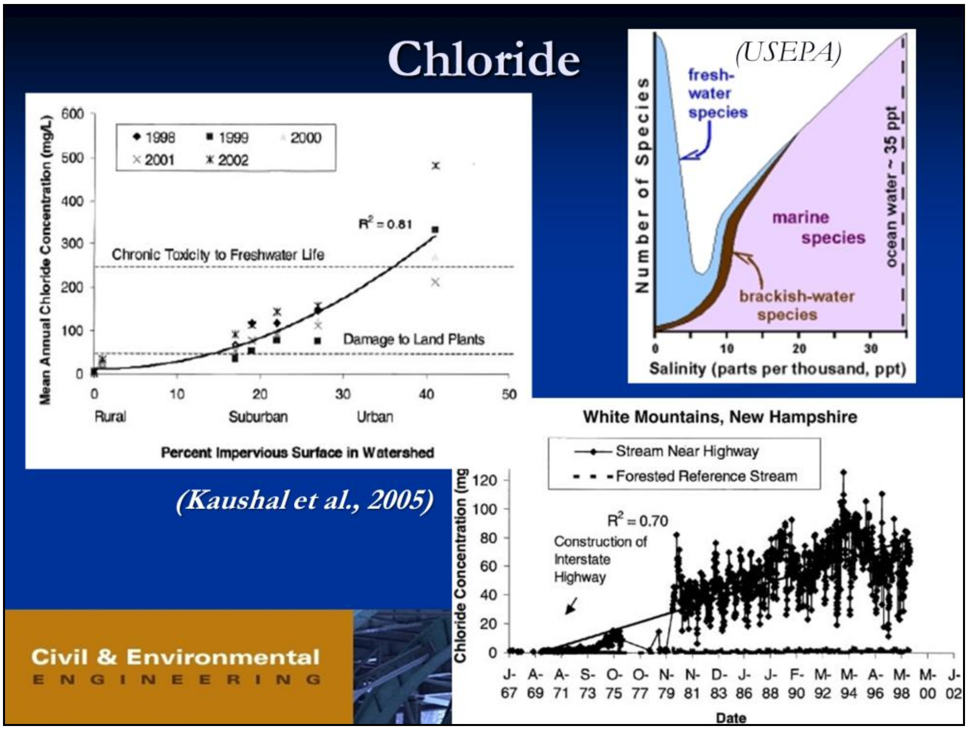
Excess nutrients lead to higher levels of algae. The algae grow, die and sink to the bottom where the biomass is consumed by bacteria. The growing bacteria consume the oxygen in the bottoms waters which cannot be replenished by mixing with the waters above.



This slide shows the percentage of years that sections of LIS go hypoxic

- CT River largest freshwater input to Sound

- Western LIS has decreased mixing and very high contributions of sewage



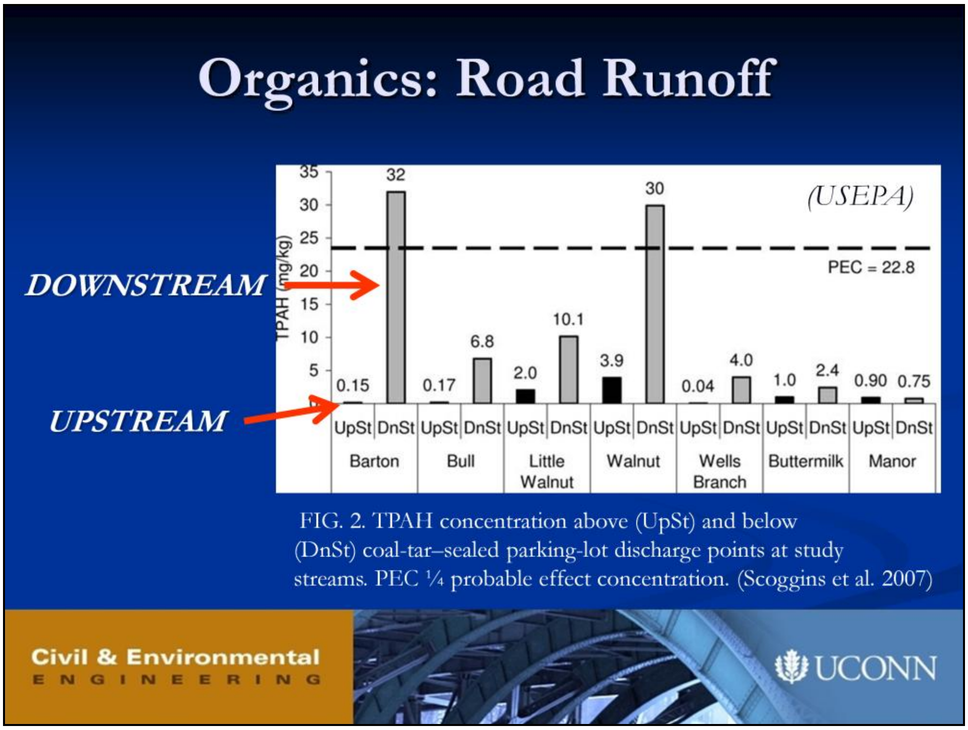
Chloride levels increasing with urbanization – a growing problem in northern areas due to the use of road salt:

-Chloride can have deleterious effects on biota, even at very low levels

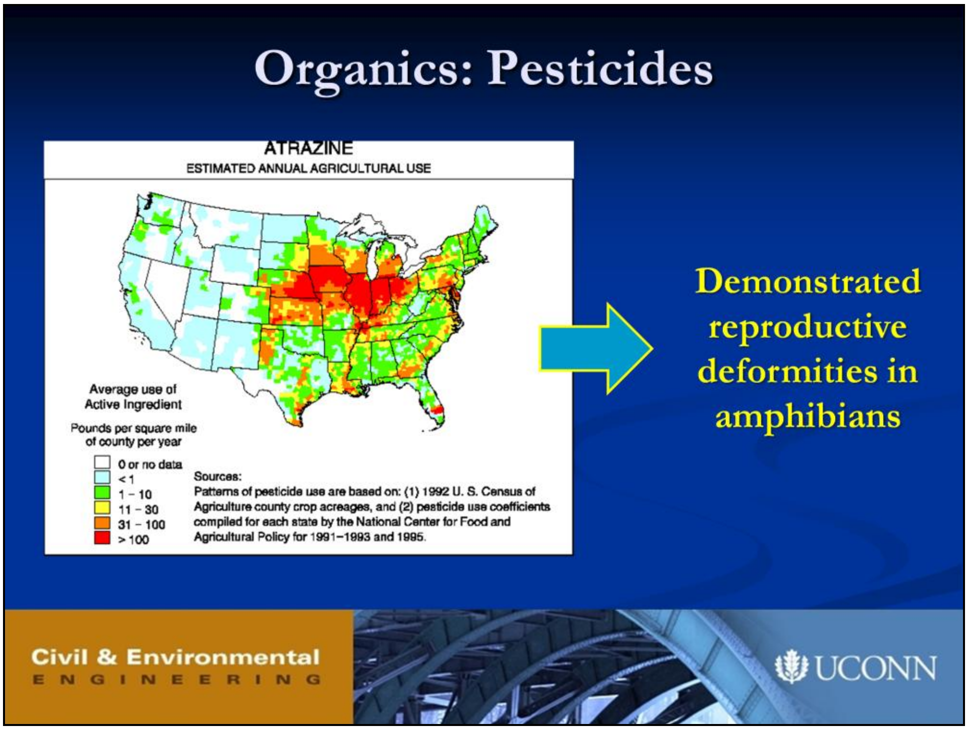
-Does not react and is generally viewed as “conservative” in the environment.

-Higher chloride levels can decrease biotic richness – the distribution of species – in freshwater environments.

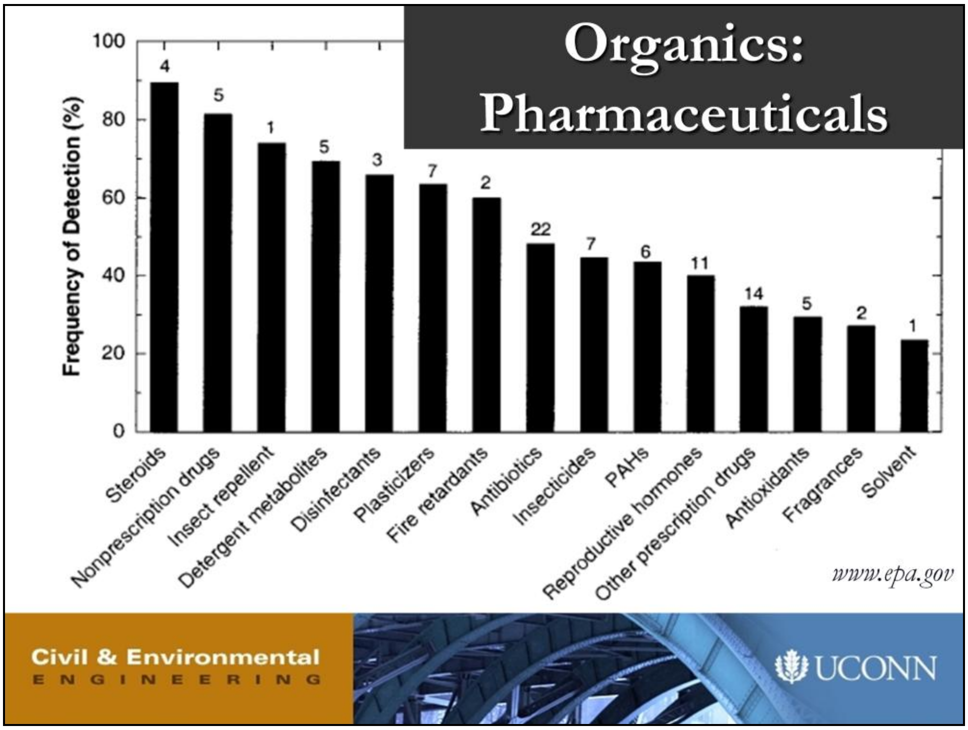
Roadways also contribute many additional contaminants from auto wear. Many of these metals are toxic at very low levels – however, must generally have VERY high levels of contributions to reach hazardous levels. Although elevated, generally not a concern for individual roadways.



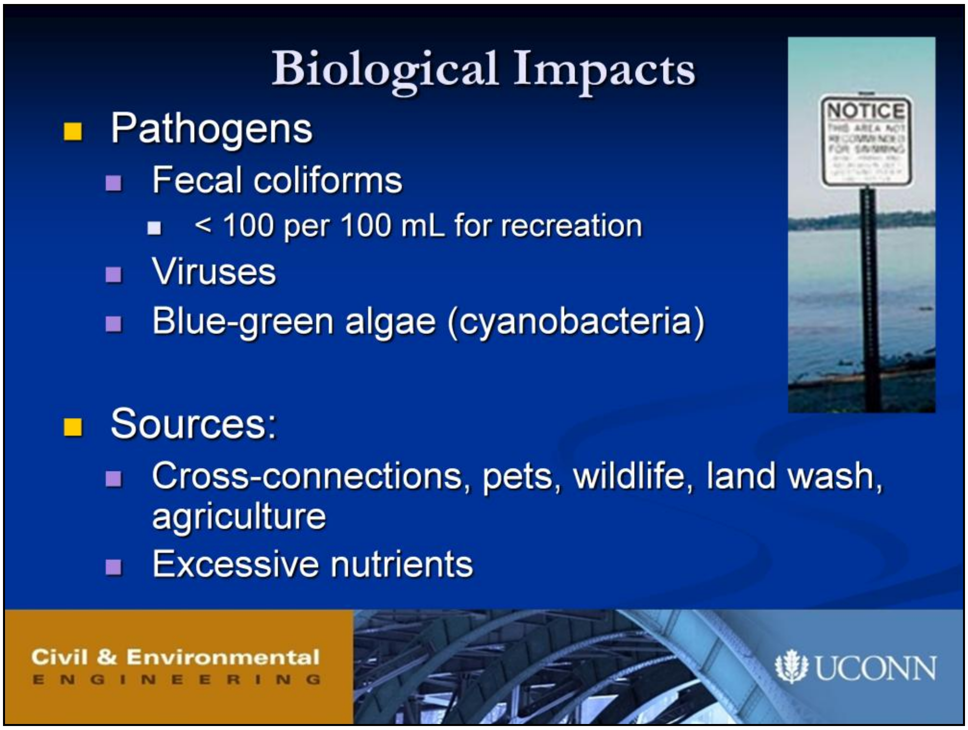
Recent research has also demonstrated higher levels of organic petroleum products in streams due to paving materials, namely coal-tar sealant.



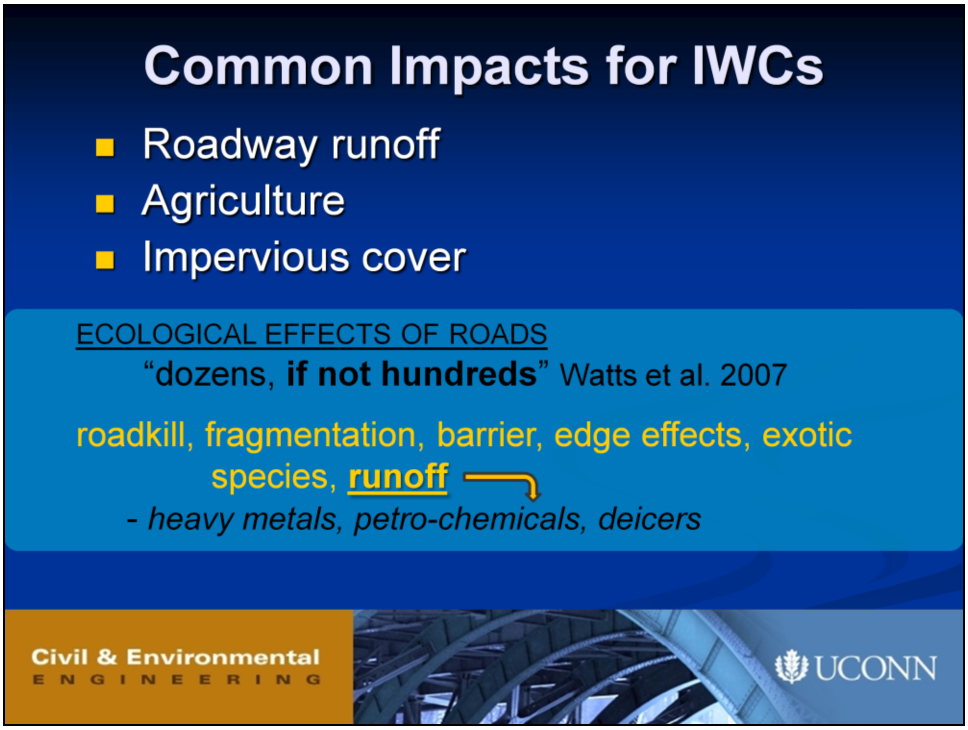
Farming contributes significant amounts of pesticides which run off from fields or reach groundwater via infiltration. Atrazine is a notable example, applied to corn crops. Note the correlation with the corn-growing regions. Atrazine use has been banned by the European Union – ironic given that the chemical is produced by a Swiss company.



Many of our personal care products and other daily use products contain chemicals aimed at preservation. We also use specific drugs which are not completely processed by our bodies. These chemicals are not completely removed in our wastewater treatment plants.

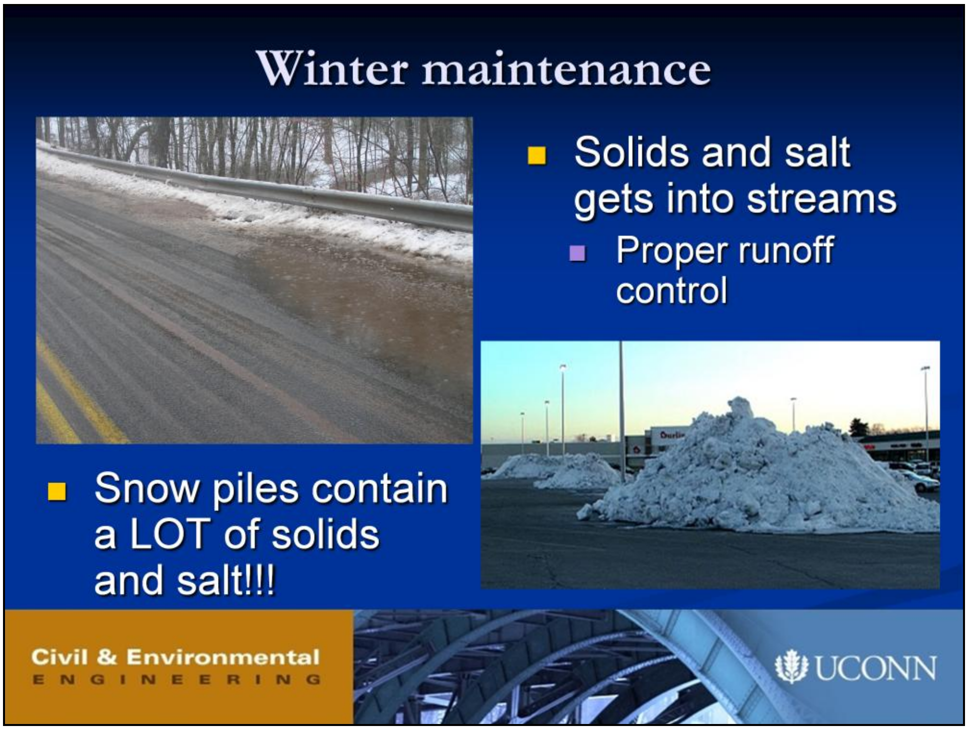


Pathogens are very difficult to track, unless you know of specific problems or potential sources. The non-point nature of most cases makes this difficult.



Some common examples IWC may encounter …. we'll start with roads.

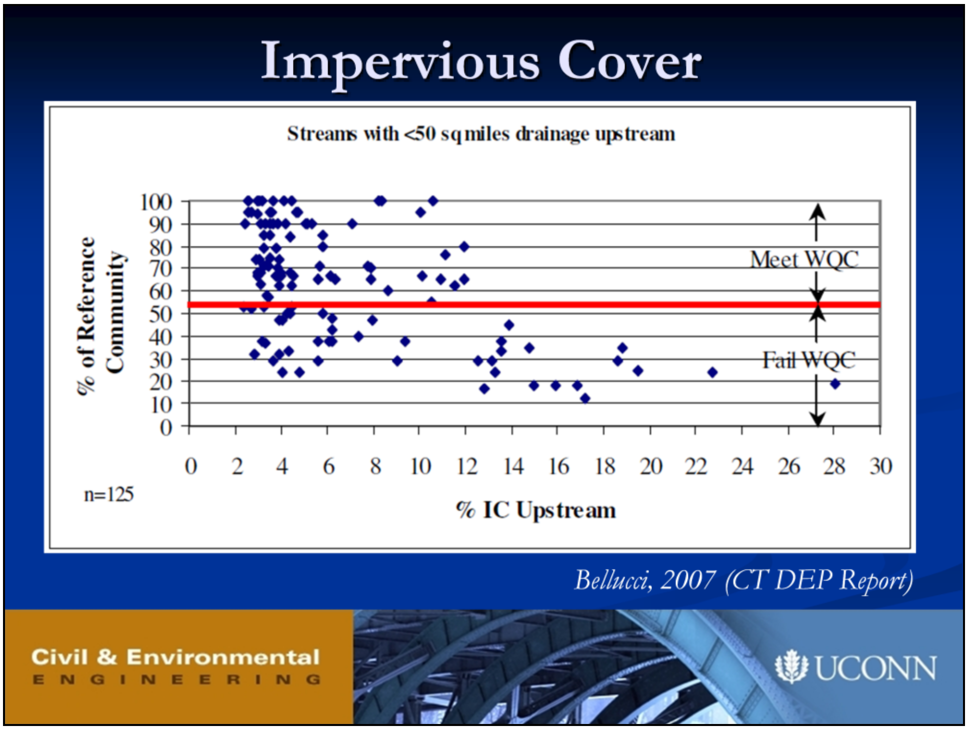
The first two pictures demonstrate the potential for stream bank erosion due to high flow. In the left side, you can see the pipe depositing water into the stream channel. The bottom two show how solids can run off from barren sites, particularly construction sites, and into water bodies. Note that in the lower left picture barrier of hay bales has been placed to filter sediment. However, the system is obviously failing.



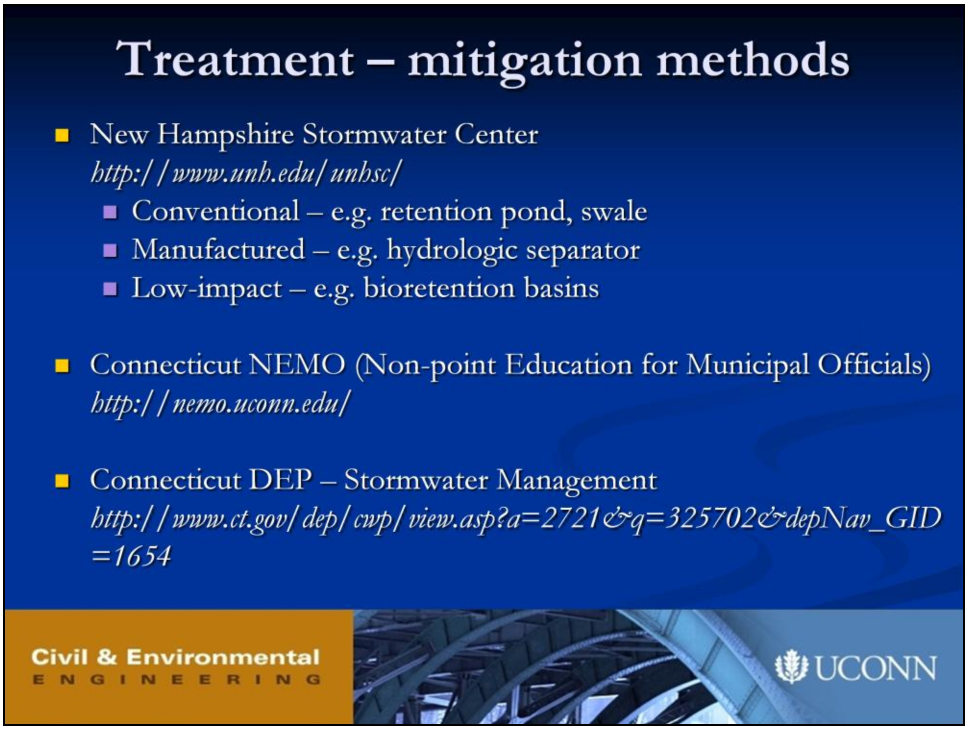
To enable travel during snowstorms, salt and sand are applied to the roadway. These are two contaminants that much subsequently be accounted for in stormwater contributions to nearby waterways when the snow melts. Solids are generally more of an issue in CT due to the relatively rural nature of the state. However, in urban areas the chloride could also be a problem during not just the winter, but also the low-flow summer period when groundwater contributions are high. The cations associated with the salt, e.g. Na+, can also negatively impact water bodies.

The need to mitigate stormwater prevents dumping straight to the stream! Piles still contain a LOT of solids that can run off during melt.

Animal waste needs to have the benefit of groundwater interception and plant/biological activity to remove nutrients. Need to also apply fertilizer to maximize uptake by the plants rather than runoff.

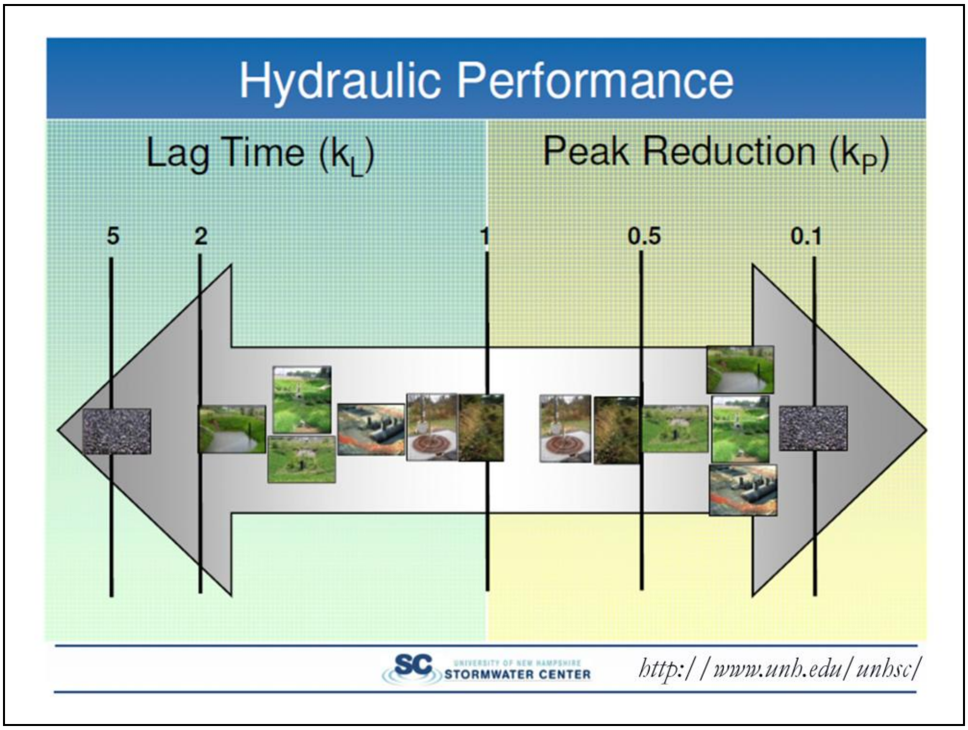


Impervious cover represents high flow, chemical addition, increased temperature and decreased riparian areas. This leads to worse water quality. A study by the CT DEP of state water bodies suggests that the magic cutoff appears to be ~12%. Above this range, the percentage of the reference species falls below acceptable standards. UConn, with Eagleville Brook, has the first impervious cover TMDL in the nation.

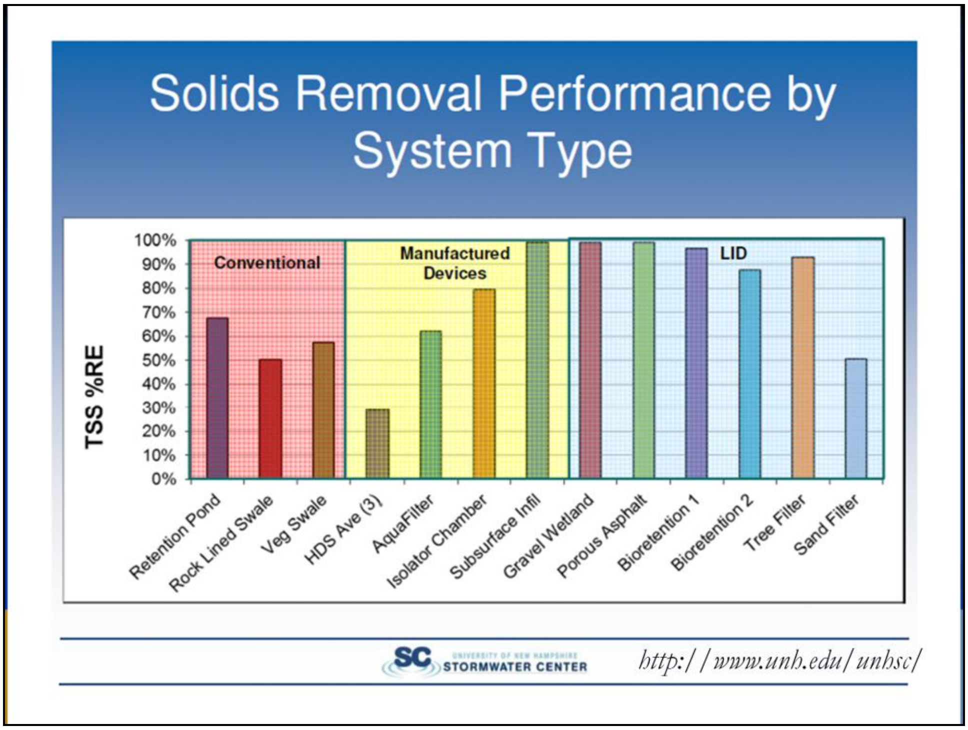


The NH Stormwater Center is the pre-eminent source for stormwater treatment information. They have installed on campus an array of treatment possibilities for long-term investigation regarding performance at hydrologic and chemical mitigation. CT NEMO and the CT DEP also have tremendous information as well on stormwater mitigation.

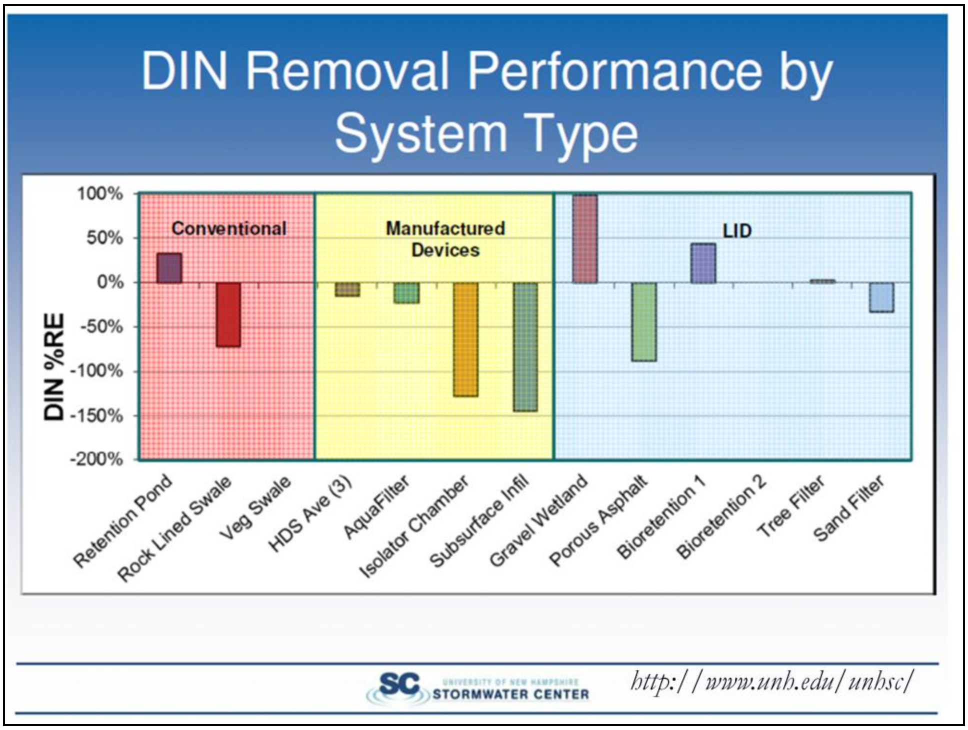
A few of the examples of stormwater mitigation technology. These span the range of conventional, manufactured and low-impact approaches.



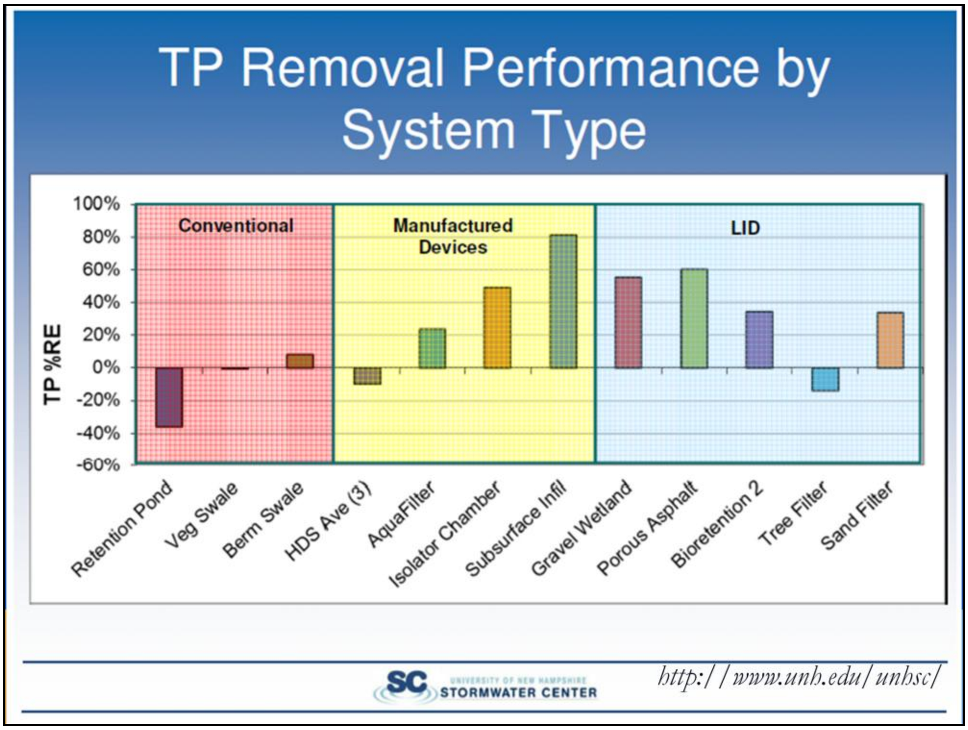
Hydraulic reduction and attenuation of the time until the peak water occurs is one performance measure. Above are a few examples: for peak reduction the porous pavement performed best with the tree filters worst. Similar for the delay to peak with the tree filter outperforming only the swale.



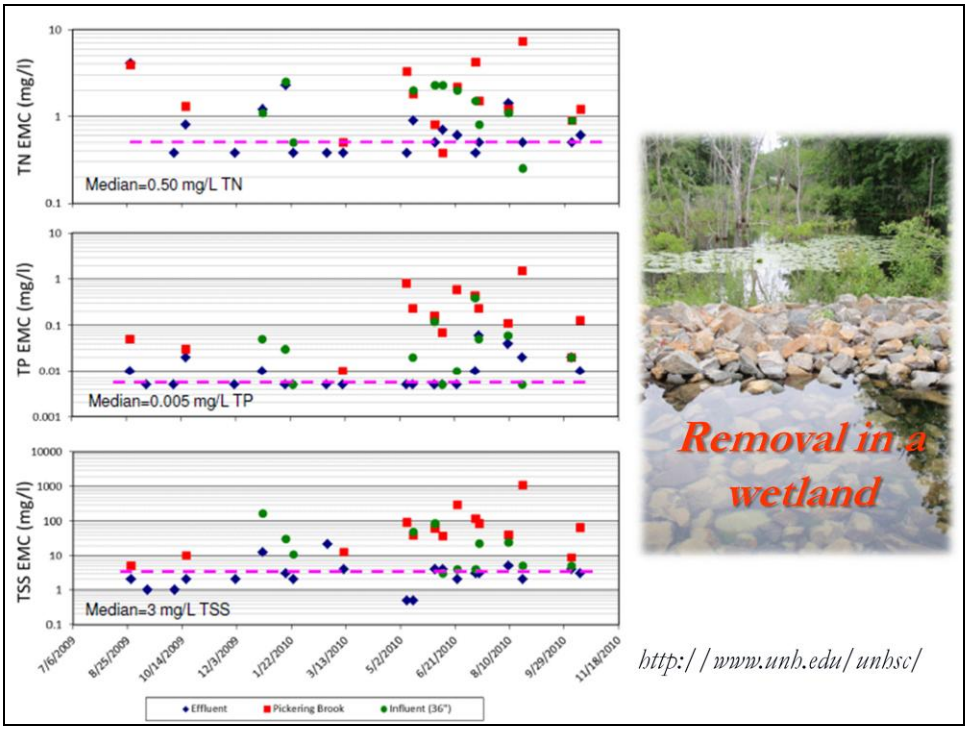
Conventional treatment of retention ponds and swales achieve 50-70% removal of solids. Some manufactured devices perform worse while others achieve almost 100%. Many LID features achieve 90-100% removal – the exception being the sand filter.



Dissolved nitrogen is difficult to remove based on the multiple water chemical conditions required for complete removal. Note that many of the devices lead to negative removal – or increasing concentrations!!! Retention ponds remove DIN while many manufactured devices release DIN. Generally those techniques involving biological methods with some retention of water will remove DIN.



Many manufactured and LID devices remove TP due to high retention of solids. The P is attached to the solids and thus removed. Retention ponds create conditions under which P is released from the sediments and can be mobilized in the water during high flow events – hence the negative removal.

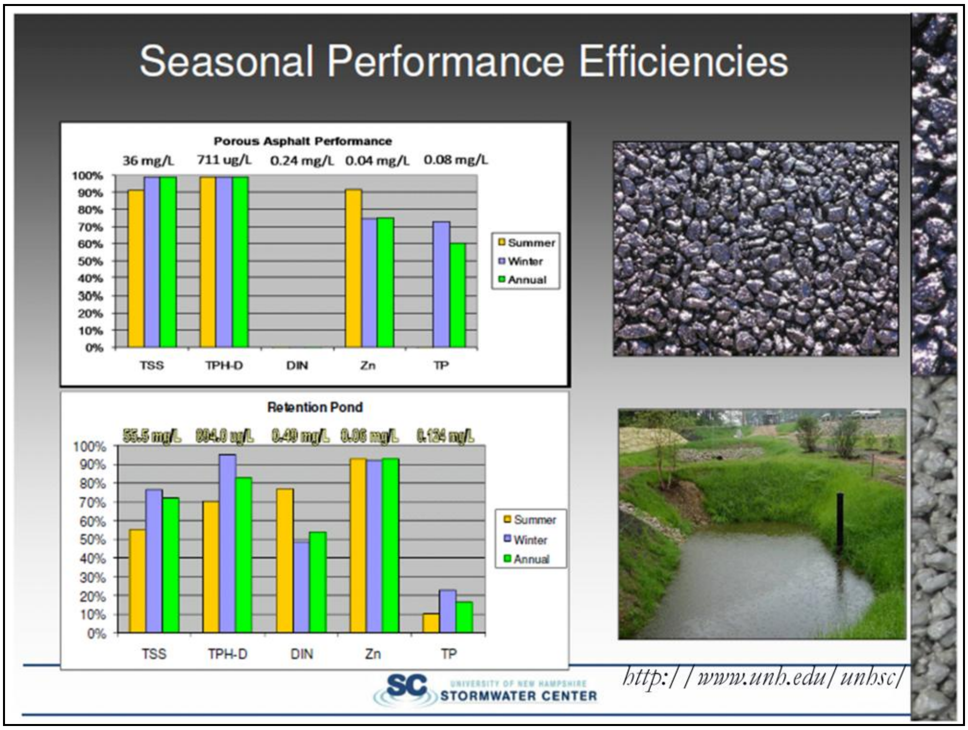


EMC = effect mean concentration

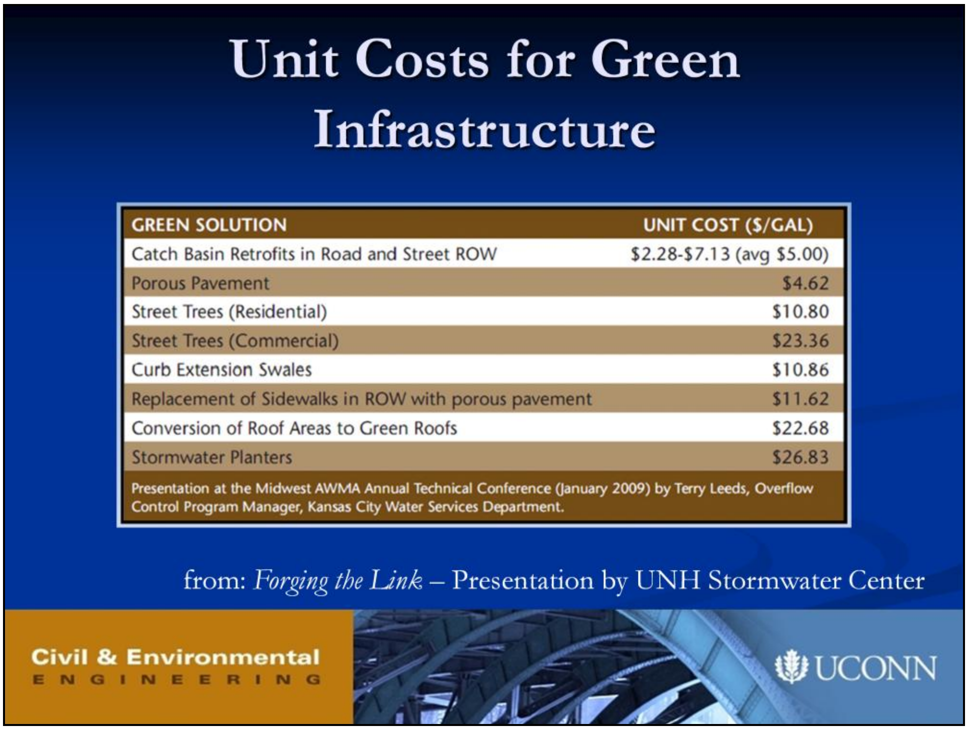
Chemicals on a log scale

Note the removal between the inlet (green), effluent (blue) and then the brook water quality (red)

Total values – reflect nutrients associated with solids



Generally porous asphalt performs well for those chemicals relating solid concentrations. Retention ponds also remove solids but achieve greater removal of DIN as well. Dissolved contaminants are more difficult to remove. Nitrogen is regulated off the dissolved portion. Metals are only regulated in their total concentration. while much lower in concentration, the dissolved portion often represents the more toxic form.



Costs are variable and will depend on site conditions. Above are costs per volume stormwater reduction given by the NH Stormwater Center. However, I’ve come across higher numbers for porous pavement and lower values for swales.

Summary

- Stream water quality not always as it appears
  - Variable in “symptoms” and toxicity
  - Physical, chemical and ecological impacts
- Situations “most relevant” to IWC
  - Stormwater quantity / sediment
  - Nutrients
- Proper mitigation measures key
  - Driven by common sense
  - SW quantity reduction, biological measures

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Questions?

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