Contamination of Stormwater Pond Sediments by Polycyclic Aromatic Hydrocarbons (PAHs) in Minnesota

The Role of Coal Tar-based Sealcoat Products as a Source of PAHs

Minnesota Pollution Control Agency

March 2010

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Document number: tdr-g1-07

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We thank Scott Andre (Minnesota Pollution Control Agency; MPCA) for graphics assistance and Amy Garcia (MPCA) for preparing maps showing the locations of Municipal Separate Storm Sewer Systems (MS4) statewide and in the Twin Cities metropolitan area. An internal draft report was reviewed by Mary Jean Fenske (Supervisor of Environmental Data Management Unit, Environmental Analysis and Outcomes Division) and Dale Thompson (Supervisor of Municipal Stormwater Unit, Municipal Division) of the MPCA. Their review comments were incorporated into the external draft report that was subsequently reviewed, all or part, by the following experts and stakeholders:

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- Randy Neprash, P.E., Bonestroo and technical consultant to the Minnesota Cities Stormwater Coalition; and
- Representative Bev Scalze, Minnesota State Representative, 54B.

Dale Thompson conducted a final review of the final draft report. Jackie Brasuhn assisted with the final word processing of this report.

List of Acronyms and Abbreviations

A	Anthracene
AOC	Area of Concern
ATSDR	Agency for Toxic Substances and Disease Registry
BaA	Benzo[a]anthracene
BaP	Benzo[a]pyrene
B[a]P	Benzo[a]pyrene
BbF	Benzo[b]fluoranthene
BeP	Benzo[e]pyrene
BHC	Benzene Hexachloride
BkF	Benzo[k]fluoranthene
BMP	Best Management Practice
C	Chrysene
CAS	Chemical Abstract Service
CCME	Canadian Council of Ministers of the Environment
CG	Carbonaceous Geosorbents
CM	Carbonaceous Materials
DBT	Dibenzothiophene
DC	District of Columbia
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenylethylene
DDT	Dichlorodiphenyltrichloroethane
DFL	Democratic Farmer Labor Party
DMP	Dimethylphenanthrene
DW	Dry Weight
EPA	Environmental Protection Agency
FFPI	Fossil Fuel Pollution Index
FL	Fluoranthene
FL/PY	Fluoranthene to Pyrene Ratio
ft	Feet
g	Gram
GC/MS	Gas Chromatography/Mass Spectrometry
HF	House File
HPAHs	High Molecular Weight PAHs
HPLC	High Performance Liquid Chromatography
IRIS	Integrated Risk Information System
kg	Kilogram
L	Liter
LCCMR	Legislative-Citizen Commission on Minnesota Resources
LIF	Laser Induced Fluorescence
LPAHs	Low Molecular Weight PAHs
m	Meter
MCL	Maximum Contaminant Level
MDH	Minnesota Department of Health
mg	Milligram
MGP	Manufactured Gas Plants
MI	Michigan
mL	Milliliters
MN	Minnesota
Mn/DOT	Minnesota Department of Transportation
MP	Methylphenanthrene
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System

List of Acronyms and Abbreviations (continued)

N	Number of Samples
ND	Nondetect
NJ	New Jersey
No.	Number
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NURP	National Urban Runoff Program
NYSDEC	New York State Department of Environmental Conservation
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
P	Phenanthrene
P/A	Phenanthrene to Anthracene Ratio
PAHs	Polycyclic Aromatic Hydrocarbons
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PCDD/Fs	Polychlorinated Dibenzo-*p*-dioxins/Dibenzo Furans
PEC	Probable Effect Concentration
PEC-Q	Probable Effect Concentration Quotient
PFCs	Perfluorochemicals
PY	Pyrene
RCRA	Resource Conservation and Recovery Act
SIM	Selective Ion Monitoring
SPME	Solid-Phase Microextraction
SQG	Sediment Quality Guideline
SQT	Sediment Quality Target
SRV	Soil Reference Value
TEC	Threshold Effect Concentration
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalent
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TSCA	Toxic Substances Control Act
TU	Toxic Unit
TX	Texas
µg	Microgram
UNHSC	University of New Hampshire Stormwater Center
US	United States
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
UV	Ultraviolet
WA	Washington
WDNR	Wisconsin Department of Natural Resources
WI	Wisconsin
wt.	Weight
XRF	X-ray Fluorescence
∑	Summation

Glossary

Acute Toxicity – The immediate or short-term response of an organism to a chemical substance. Lethality is the response that is most commonly measured in acute toxicity tests.

Anthropogenic – Pertains to the influence of human activities.

Asphalt – A brownish-black solid or semisolid mixture of bitumens obtained from native deposits or as a petroleum byproduct, used in paving, roofing, and waterproofing. May be mixed with crushed stone or sand for paving.

Aquatic Ecosystem – All the living and nonliving material interacting within an aquatic system (e.g., pond, lake, river, ocean).

Aquatic Organisms – All of the species that utilize habitats within aquatic ecosystems (e.g., aquatic plants, invertebrates, fish, and amphibians).

Area of Concern – One of 43 Areas of Concern designated in the Great Lakes basin by the International Joint Commission. Each AOC must go through a multi-stage remedial action plan process.

Benthic Invertebrate Community – The assemblages of various species of sediment-dwelling organisms that are found within an aquatic ecosystem.

Best Management Practices (BMPs) – Methods used to control nonpoint source pollution by modifying existing management practices. BMPs include the best structural and non-structural controls and operation and maintenance procedures available. BMPs can be applied before, during and after pollution-producing activities, to reduce or eliminate the introduction of pollutants into receiving waters.

Bioaccumulation – The net accumulation of a chemical substance by an organism as a result of uptake from all environmental sources.

Bioavailability – The availability of a substance to be taken up by biological organisms.

Black Carbon – The residual elemental carbonaceous products of biomass (e.g., forest fires, residential wood burning) and fuel combustion (e.g., traffic, industry, coal, oil) that may end up in soil, sediment, and the air. Black carbon is composed of soot and char. Hydrophobic organic chemicals may sorb strongly to it, affecting their bioavailability to organisms.

Bulk Sediment – Sediment and associated pore water.

Carbonaceous Geosorbents – Material in sediments composed of black carbon, coal, and kerogen, which increases the sorption of hydrophobic organic contaminants.

Chemical Benchmark – Guidelines for water or sediment quality which define the concentration of contaminants that are associated with high or low probabilities of observing harmful biological effects, depending on the narrative intent of the guideline.

Chemicals of Potential Concern – The concentrations of chemical substances that are elevated above anthropogenic background and for which sources of these chemicals can be identified in the watershed (also called potential chemicals of concern).

Chronic Toxicity – The response of an organism to long-term exposure to a chemical substance. Among others, the responses that are typically measured in chronic toxicity tests include lethality, decreased growth, and impaired reproduction.

Coal Tar – Coal tar is a byproduct of the coking of coal and can contain 50% or more PAHs by weight.

Contaminants of Concern – The chemical substances that occur in sediments at levels that could harm sediment-dwelling organisms, wildlife, or human health (also called chemicals of concern).

Contaminated Sediment – Sediment containing chemical substances at concentrations that pose a known or suspected threat to environmental or human health.

Diagenetic PAHs – These PAHs arise from biogenic precursors, like plant terpenes, leading to the formation of compounds such as retene and derivatives of phenanthrene and chrysene.

Dredged Material -- Includes material that is excavated at or below the Ordinary High Water Level of water basins, water courses, public waters, or public waters wetlands, as defined by Minn. Stat. 105G.005.

Dredging – Removal of material from the bottom of a water body by excavation or similar removal activity.

Ecosystem – All the living (e.g., plants, animals, and humans) and nonliving (rocks, sediments, soil, water, and air) material interacting within a specified location in time and space.

Epibenthic Organisms – The organisms that live on the surface of bottom sediments.

Exposure – Co-occurrence of, or contact between, a stressor (e.g., chemical substance) and an ecological component (e.g., aquatic organism).

Hot Spot – An area of elevated sediment contamination.

Hydrophobic Organic Chemical – Hydrophobic refers to the tendency of a substance to repel water or to be incapable of completely dissolving in water. Hydrophobic organic chemicals (e.g., PAHs, PCBs, and organochlorine pesticides) are readily soluble in many nonpolar solvents, such as octanol, but only sparingly soluble in water, a polar solvent. These chemicals tend to accumulate in lipids and organic carbon.

Infaunal Organisms – The organisms that live in bottom sediments.

Kerogen – The solid, insoluble organic matter that occurs in source rocks which can yield oil upon heating.

Level I SQT – Chemical concentrations which will provide a high level of protection for benthic invertebrates.

Level II SQT – Chemical concentration which will provide a moderate level of protection for benthic invertebrates.

Mean PEC-Q – A screening tool to compare sediment quality between sites. In interpreting the results, though, one must consider whether other contaminants of concern contribute to risk and whether the extent and magnitude of contamination has been adequately characterized. The mean PEC-Qs have been shown to provide a reliable basis for classifying sediments as toxic or not toxic in the St. Louis River Area of Concern, and this relationship may hold for other Minnesota waters.

Metals – Metals include elements with a metallic luster and are found on and beneath the earth's surface, such as iron, manganese, lead, cadmium, zinc, nickel, and mercury.

Nonpoint Source Pollution – Pollution sources that are diffuse, without a single identifiable point of origin, including runoff from agriculture, forestry, and construction sites.

Nutrients – Substances such as nitrogen and phosphorus compounds necessary for growth and survival. Elevated concentrations can cause unwanted growth of algae, and can result in the lowering of the amount of oxygen in the water when the algae die and decay.

Pesticides – A class of hazardous substances (either naturally occurring or chemically synthesized) that are used to kill pests. This class includes insecticides (which kill insects), herbicides (which kill weeds), fungicides (which kill fungus and molds), algicides (which kill algae), and rodenticides (which kill rodents, such as rats and mice). Pesticides can accumulate in the food chain and/or contaminate the environment if misused.

Petrogenic PAHs – These PAHs are created by diagenetic processes at relatively low temperatures over geologic time scales, leading to the formation of petroleum and other fossil fuels containing PAHs.

Polychlorinated Biphenyls (PCBs) – PCBs are a mixture of up to 209 hydrophobic organic chemicals produced by chlorination of biphenyl. PCBs were used for a variety of purposes including electrical applications, carbonless copy paper, adhesives, hydraulic fluids, and caulking compounds. Due to their accumulation in the food chain, production of PCBs was halted world-wide at the beginning of the 1980s. However, these chemicals still persist in the environment.

Polycyclic Aromatic Hydrocarbons (PAHs) – PAHs are ubiquitous environmental contaminants, some of which are formed by the incomplete combustion of organic materials, such as wood or fossil fuels. PAH molecules are made up of three or more benzene rings. PAHs form a large and heterogeneous group, but the most toxic ones are PAH molecules that have four to seven rings. The higher molecular weight PAHs (e.g., fluoranthene, benzo[a]pyrene) are products of combustion. The lower molecular weight PAHs (e.g., naphthalene, fluorene) are generally derived from unburned petroleum sources and alkylated PAHs.

Pore water – The water that occupies the spaces between sediment particles.

Probable Effect Concentrations (PECs) – The probable effect concentrations that were developed from published sediment quality guidelines of similar narrative intent.

Pyrogenic PAHs – These PAHs result from the incomplete combustion of organic matter at high temperature and for a short duration.

Sealcoat – A black liquid that is sprayed or painted on asphalt pavement in order to protect and beautify the asphalt. Sealcoat manufacturers recommend reapplication every 2 to 3 years. Most sealcoat products are coal tar or asphalt-based. Many coal tar sealcoat products contain 15 - 35% coal tar by weight.

Sediment **–** Loose particles of sand, clay, silt, and other substances that settle to the bottom of a body of water. Sediment can come from the erosion of soil or from the decomposition of plants and animals. Wind, water, and ice often carry these particles great distances.

Sediment Chemistry Data **–** Information on the concentrations of chemical substances in bulk sediments or pore water.

Sediment-Dwelling Organisms – The organisms that live in, on, or near bottom sediments, including both epibenthic and infaunal species.

Sediment Quality Guideline (SQG) – Chemical benchmark that is intended to define the concentration of a sediment-associated contaminant that is associated with a high or a low probability of observing harmful biological effects or unacceptable levels of bioaccumulation, depending on its purpose and narrative intent.

Sediment Quality Target (SQT) – Chemical benchmarks for the St. Louis River AOC that have been adopted for use throughout Minnesota. See Level I SQT and Level II SQT.

Storm Sewers – The underground infrastructure designed to collect storm runoff from urban areas which is typically not treated by sewage treatment facilities before it is discharged into nearby surface waters.

Stormwater – Rainwater runoff, snow melt runoff, surface water runoff, and discharges that are collected by storm sewers.

Stormwater Pond **--** A treatment pond constructed and operated for water quality treatment, storm water detention, and flood control. Stormwater ponds do not include areas of temporary ponding, such as ponds that exist only during a construction project or provide for the short-term accumulations of water in road ditches.

Threshold Effect Concentrations (TECs) – The threshold effect concentrations that were developed from published sediment quality guidelines of similar narrative intent.

Total Maximum Daily Load (TMDL) – TMDLs are set by regulators to allocate the maximum amount of a pollutant that may be introduced into a water body and still assure attainment and maintenance of water quality standards.

Wildlife – The reptiles, amphibians, birds, and mammals associated with aquatic ecosystems as referred to in this report [e.g., piscivorous (fish eating) wildlife].

Executive Summary

Stormwater ponds are filling up with contaminated sediment (i.e., mud) throughout Minnesota, and many cities have not yet routinely included the costs of removing these sediments in their budgets. A common class of urban pollutants, polycyclic aromatic hydrocarbons (PAHs), are the most likely contaminants of concern in these sediments. In some cases, concentrations of PAHs are high enough to warrant expensive disposal of the dredged material in specially lined landfills. In these situations, cities are stymied by limited reuse options and disposal cost issues for removing the sediments. As such, PAH-contaminated stormwater ponds are an important emerging issue in Minnesota for the following reasons:

- Most cities have slowed maintenance of their stormwater ponds after high concentrations of PAHs were found in several pond sediments, including those from White Bear Lake, MN.
- Cities need to periodically remove sediments from stormwater ponds to maintain function, and disposal costs are inhibiting them from doing so now. Thus, some stormwater ponds are not working effectively.
- Cities have requested a solution from the Minnesota Pollution Control Agency (MPCA).
- Local news media (e.g., St. Paul Pioneer Press, KARE 11 News, Minnesota Public Radio) have taken up this issue, increasing public awareness and expectations for action.
- Potential consequences of not properly addressing this issue include:
    - Municipalities may move forward and inappropriately dispose or reuse sediments dredged out of their stormwater ponds, resulting in potential risk to human health and the environment.
    - As stormwater ponds fill with sediment, these structures will lose their water quality functionality resulting in a greater load of contaminants and suspended sediments to downstream receiving waters.
    - In filled stormwater ponds, sediment-bound PAHs may be resuspended and transported to downstream receiving waters, resulting in potential impacts to aquatic biota. For example, PAHs could kill or impair bottom-feeding (benthic) organisms that comprise part of the aquatic food chain for fish, resulting in less fish for anglers to catch. In addition, PAHs can also cause external tumors on fish, raising concerns from the public.
    - Improper sediment disposal and/or reuse decisions may be made without knowing if emerging contaminants (e.g., perfluorochemicals, pyrethroids, and polybrominated diphenyl ether flame retardants) are of concern in stormwater pond sediments.
    - Stormwater ponds will fill up with sediment, adversely impacting water quality and increasing public concerns about mosquito-borne encephalitis and West Nile virus. In addition, these marshy stormwater ponds may harbor toxic blue-green algae and other nuisance algae and duckweed.

The MPCA is concerned about this issue. This technical paper was assembled for environmental professionals, decision makers, and interested stakeholders to elucidate the growing problem of PAH-contaminated stormwater pond sediments in Minnesota and to provide the technical rationale to support local or state-wide bans on the purchase of coal tar sealcoat products in Minnesota that contribute to this contamination. In particular, this paper includes the following components:

- Provide background information on stormwater ponds, as well as their use in Minnesota;
- Document the latest scientific research on PAHs in aquatic and near-shore environments, including:
    - The physical/chemical properties of PAHs that contribute to their persistence in the environment; and
    - The risk these compounds pose to aquatic organisms, piscivorous (i.e., fish eating) wildlife, and human health through sediment-related exposure pathways.
- Describe screening benchmarks for PAHs in soil and sediment;

- Discuss the most likely sources of PAHs to urban stormwater ponds in Minnesota, including studies of PAH transport from parking lots treated with asphalt-based and coal tar-based sealcoats;
- Summarize data on the distribution of PAHs in stormwater pond sediments in Minnesota and elsewhere in the United States (primarily South Carolina), as well as general issues on the distribution of PAHs in Minnesota waterways;
- Discuss management options for addressing this issue; and
- Provide recommendations for next steps to move forward on providing guidance to municipalities on how to maintain the effectiveness of their stormwater ponds.

Polycyclic aromatic hydrocarbons (PAHs) are organic chemicals that persist in the environment and pose a risk to animals, plants, and people at elevated concentrations. These contaminants are formed by the incomplete combustion of organic materials, such as wood, oil, and coal, as well as occurring naturally in crude oil and coal. Oftentimes, a mixture of sources may contribute to the assemblage of PAHs measured in environmental samples. Due to their unique physical/chemical properties, PAHs tend to attach to particles in the air, water, and sediment and also accumulate in the lipids (i.e., fat) of benthic organisms that are unable to metabolize them. Although fish are able to metabolize PAHs, lessening their accumulation in tissues, PAHs can cause other detrimental effects in fish such as mouth tumors. Consequently, sediments of urban waterways (e.g., stormwater ponds, lakes, rivers, and harbors) are oftentimes contaminated with a background signature of PAHs. Other watershed sources of PAHs can further elevate contaminant concentrations in sediments. PAHs can persist in sediments for a long period of time.

Sealcoats are applied to the surface of asphalt walkways, playgrounds, driveways, and parking lots in order to protect the asphalt pavement and to provide a deep black appearance for cosmetic purposes. There are two main types of sealcoat products: asphalt emulsion-based and coal tar emulsion-based. Asphalt-based sealcoats are made from refined petroleum products while the coal tar-based sealcoats are made from refined coal tar, a by-product of coke production. Although both of these products contain PAHs, concentrations of PAHs by weight are low (usually <1%) in asphalt-based products and high (up to about 30%) in coal tar-based products.

Coal tar-based sealcoats are emerging as important sources of PAHs to urban waterways in several parts of the United States, including the upper midwest. Several recent studies by the U.S. Geological Survey and others have provided clear and compelling evidence regarding the magnitude of this problem, particularly from pavement dust and stormwater runoff of driveways and parking lots treated with coal tar-based sealcoat products.

In light of some of these studies, three municipalities in the United States have banned the use of coal tar-based sealcoat products since asphalt-based sealcoats are an acceptable alternative. In the 2009 Minnesota legislative session, a ban on the use of coal tar-based sealcoats by state agencies was implemented beginning July 1, 2010. In addition, the State of Minnesota will make grant funding available in state fiscal year 2011 for municipalities to implement best management practices (BMPs) to treat or clean-up contaminated sediments in their stormwater ponds. This funding will only be available to local governments that have adopted an ordinance restricting usage of coal tar-based sealcoat products, unless a statewide restriction has been implemented by then.

Many of the stormwater ponds in Minnesota are over 15 years old and are filling up with sediment that must be removed to maintain their efficiency. The MPCA regulates the stormwater discharges of only 235 entities in Minnesota with oversight of ponds through the Municipal Separate Storm Sewer System (MS4) permit program of the National Pollutant Discharge Elimination System (NPDES). The MS4 program is designed to reduce the loading of suspended sediment and pollutants to surface and groundwater from storm sewer systems to the maximum extent possible. The MS4 permits are held by a variety of groups, including municipalities, watershed districts, the Minnesota Department of Transportation (Mn/DOT), counties, universities, and community colleges. A single MS4 permit may encompass hundreds of stormwater ponds. Other stormwater ponds are the responsibility of private homeowner associations, businesses, and communities not included in the MS4 permit program.

The MPCA's management options regarding PAH-contaminated stormwater ponds can generally be classified as follows:

- Pollution prevention efforts to reduce the use of PAHs in products that could be emitted into stormwater runoff;
- Source control efforts to reduce sources of PAHs to the environment;
- Implementation of BMPs to reduce the transport of PAHs to stormwater ponds;
- Remediation of PAH-contaminated stormwater pond sediments; and
- Adoption of beneficial reuse options for less contaminated sediments, such as zones of cleaner sediments in stormwater ponds or those sediments that have been remediated.

Implementation of a combination of management options may provide the most flexibility and success with addressing this issue.

This report also provides a number of recommendations to move forward on addressing the problem of PAH-contaminated stormwater pond sediments and to provide municipalities with guidance. These recommendations can be summarized briefly as follows:

- Educate the public and stakeholders about pollution prevention strategies that will reduce sources of PAHs, including the reduction or elimination of PAHs in sealcoat products applied to driveways and parking lots;
- Implement the coal tar policy provisions passed in the 2009 legislative session, including:
    - Notify state agencies and local units of government by January 15, 2010, of the potential for contamination of constructed stormwater ponds and wetlands, or natural ponds used for the collection of stormwater via constructed conveyances, with PAHs from the use of coal tar-based sealcoat products;
    - Establish a schedule and information requirements (i.e., inventory) by January 15, 2010, for state agencies and local units of government regulated under a MS4 state disposal system permit to report on all constructed stormwater ponds and wetlands or natural ponds used for the collection of stormwater via constructed conveyances within their jurisdiction;
    - Discontinue use of any undiluted coal tar sealcoat products by state agencies after July 1, 2010;
    - Develop BMPs for state agencies and local units of government regulated under a MS4 state disposal system permit to treat or clean-up contaminated sediments in stormwater ponds and other waters defined above. The BMPs must be posted on the MPCA's Web site. As part of the development of the BMPs, the following tasks will be completed:
        - sample a set of stormwater pond sediments in residential, commercial, and industrial areas within the Twin Cities metropolitan area for PAHs and other contaminants of potential concern (e.g., perfluorochemicals, pyrethroids, and polybrominated diphenylethers),
        - investigate the feasibility of screening methods to provide cost-effective analytical results and to identify which kinds of ponds are likely to have the highest concentrations of PAHs, and
        - update guidance on testing, treatment, removal, and disposal of PAH-contaminated sediments based on this study.
    - Incorporate the requirements for an inventory and BMPs specified above into the next permitting cycle for MS4 permits;
- Monitor the University of Minnesota's progress with conducting a two-phase bioremediation study using compost to assess microbial degradation of PAHs in stormwater pond sediments. Facilitate activities that will benefit this study; and
- Examine data collected by the University of Minnesota, on behalf of the MPCA, for operation and maintenance surveys of stormwater ponds. These data may be used by the MPCA to identify more

efficient BMP practices, as well as to determine the costs associated with operating and maintaining stormwater ponds.

It was beyond the scope of this report to estimate costs associated with:

- Developing an inventory of MS4 stormwater ponds in Minnesota;
- Monitoring stormwater pond sediments for contaminants of potential concern in the MS4 program;
- Implementing dredging and sediment disposal options for MS4 stormwater ponds; and
- Considering the aforementioned costs to businesses, homeowner associations, and other owners of private ponds that were built for the protection of water quality.

It was also beyond the scope of this document to discuss related issues beyond pond sediment, such as:

- Sediment quality of other BMPs, such as sump manholes and other devices;
- Potential contamination in underground infiltration devices that receive minimal pretreatment;
- Feasibility of whether overlying water in stormwater ponds could be used for local irrigation and whether doing so would result in an unacceptable accumulation of contaminants in the soil; and
- Whether asphalt roof shingles could pose a significant source of PAHs to stormwater ponds.

For further information about the content of this report, please contact Dale Thompson, Supervisor of the Municipal Stormwater Unit, at 651-757-2776 (voice) or dale.thompson@state.mn.us.

Introduction

Stormwater ponds serve a vital function within urban areas of Minnesota. A stormwater pond is a treatment pond constructed and operated for water quality treatment, stormwater detention, and flood control. Stormwater ponds do not include areas of temporary ponding, such as sediment basins that exist only during a construction project or provide for the short-term accumulations of water in road ditches. Stormwater ponds have become a popular best management practice (BMP) for the treatment of urban stormwater runoff (Weiss *et al*. 2008). These ponds usually have a design life of about 20 - 30 years with large scale sediment removal suggested every 8 - 12 years.

The efficacy of stormwater ponds has created an unintended problem through the accumulation of potentially toxic concentrations of polycyclic aromatic hydrocarbons (PAHs) in pond sediments. PAHs are ubiquitous environmental contaminants formed by the incomplete combustion of organic materials, such as wood, oil, and coal, as well as occurring naturally in crude oil and coal. Recent research by the U.S. Geological Survey (USGS) shows that dust from coal tar-based sealcoats, followed by vehicle emissions and coal combustion, are the primary sources of PAHs to a subset of urban lakes in the midwest and east coast (Van Metre and Mahler 2009). It is likely that these coal tar-based sealcoat products are also a major source of PAHs to stormwater pond sediments in Minnesota.

Coal tar-based sealcoats are used by homeowners on asphalt-based driveways and by businesses and others on parking lots. According to Geoff Crenson, chairman of the Pavement Coating Technology Center, approximately 85 million gallons of coal tar-based sealcoat products are sold each year in the United States (Hogue 2007). Over time, the sealcoat breaks down and can be transported via runoff from rain and snowmelt events to storm sewers or as dust in the air. Although coal tar-based sealcoats are more resistant to gas and oil leaks than asphalt-based sealcoats, it contains up to 1,000 times more PAHs based on an analysis of several sealcoat products by the City of Austin, TX (McClintock *et al*. 2005). In response to this threat, local bans on the use of coal tar-based sealcoats have been implemented in Austin, TX; Dane County, WI, and Washington, DC. In these municipalities, only asphalt-based sealcoats are allowed. The Minnesota Department of Transportation (Mn/DOT) does not allow the use of coal tar sealcoats in their specifications to contractors. The 2009 Minnesota Legislature enacted a ban on coal tar-based sealcoats used by State agencies starting July 1, 2010, as well as to fund a study of PAH-contaminated stormwater pond sediments, in addition to:

- Providing notification for the potential for coal tar contamination of stormwater ponds;
- Establishing a stormwater inventory schedule;
- Developing best management practices for treating and disposing of PAH-contaminated stormwater pond sediment; and
- Providing grant incentive funding for local governments adopting coal tar bans by city ordinances in state fiscal year 2011 (http://www.house.leg.state.mn.us/comm/docs/H1973DE1.pdf).

The MPCA has provided dredged material guidance with particular applications to stormwater ponds, including: sampling and analysis requirements, describing management levels of dredged material based on comparisons to the MPCA's soil reference values, and identifying permit requirements (Stollenwerk *et al*. 2009). Minnesota is at the forefront of this issue in the United States, and other local, state, and federal agencies may benefit from the MPCA's growing experience with PAH-contaminated stormwater pond sediments when it comes time to perform maintenance dredging of their ponds.

This technical paper was assembled for environmental professionals, decision makers, and interested stakeholders to elucidate the growing problem of PAH-contaminated stormwater ponds in Minnesota and to provide the technical rationale to support local or state-wide bans on the purchase of coal tar sealcoat products in Minnesota that contribute to this contamination. In particular, this paper includes the following components:

- Provide background information on stormwater ponds, as well as their use in Minnesota;
- Document the latest scientific research on PAHs in aquatic and near-shore environments, including:

- The physical/chemical properties of PAHs that contribute to their persistence in the environment; and
- The risk these compounds pose to aquatic organisms, piscivorous (i.e., fish eating) wildlife, and human health through sediment-related exposure pathways.

- Discuss the most likely sources of PAHs to urban stormwater ponds in Minnesota, including studies of PAH transport from parking lots treated with asphalt-based and coal tar-based sealcoats;
- Summarize data on the distribution of PAHs in stormwater pond sediments in Minnesota and elsewhere in the United States (primarily South Carolina), as well as general issues on the distribution of PAHs in Minnesota waterways;
- Discuss management options for addressing this issue; and
- Provide recommendations for next steps to move forward on providing guidance to municipalities on how to maintain the effectiveness of their stormwater ponds.

Background

The National Urban Runoff Program (NURP) was the first major study of urban stormwater pollution across the United States (USEPA 1983). Conducted by the U.S. Environmental Protection Agency (EPA) during 1979 and 1983, this study found that metals like copper, lead, and zinc were the most prevalent priority pollutants in urban runoff and that wet basins (designed with a permanent water pool) had the best available performance capabilities, amongst other findings (USEPA 1983). In regards to sediments, this study noted:

> "The nature and scope of the potential long-term threat posed by nutrient and toxic pollutant accumulation in the sediments of urban lakes and streams requires further study. A related issue is the safe and environmentally sound disposal of sediments collected in detention basins used to control urban runoff."

These concerns about contaminated sediments now need to be addressed in Minnesota. Back in the 1980s when untreated stormwater runoff was one of the leading sources of nonpoint source pollution to Minnesota's waterways, the Vadnais Lake Watershed Management Organization (Vadnais Lake, MN) and the St. Paul Regional Water Supply (St. Paul, MN) pioneered the use of stormwater ponds. Most new urban developments must manage stormwater runoff to protect downstream water quality and to reduce flooding. These pond systems are now commonly used in North America and elsewhere in the world (e.g., Europe, New Zealand; Figure 1).

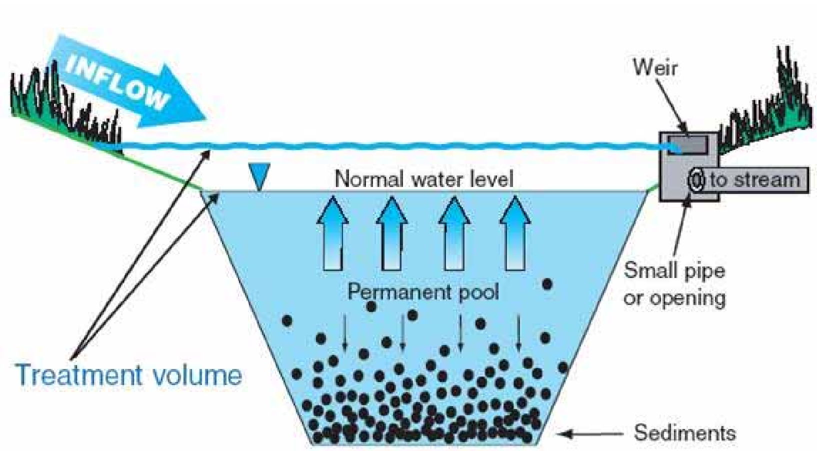


Figure 1. Diagram of a typical wet detention stormwater pond (St. Johns River Water Management District 2003).

Urban stormwater is formed when rain or melting snow runs off of impervious surfaces like roads, parking lots, driveways, rooftops, and buildings and pervious surfaces like lawns. An analysis of satellite and aerial photos of six urban and suburban watersheds scattered across the lower 48 states showed that roads accounted for about 28% of impervious surfaces, buildings were responsible for about 29%, parking lots made up nearly 25%, and driveways, sidewalks, patios, and pools made up about 14% of impervious surfaces (Slonecker and Tilley 2004). Satellite imaging was used to estimate 1.05% of the land area in the conterminous United States is impervious surface (83,337 km^2; Elvidge *et al*. 2007). Theobald *et al*. (2009) estimate the area of impervious surface cover within the United States will expand to 114,070 km^2 by 2030. Stormwater that runs off these impervious surfaces and lawns often contains a mixture of nutrients, suspended solids, bacteria, oil and grease, metals, and organic contaminants like PAHs, pesticides, and polychlorinated biphenyls (PCBs). Stormwater runoff treatment relies upon three primary processes to improve water quality and reduce contaminant loads into rivers and lakes:

1. Infiltration (e.g., rain gardens);
2. Filtration (e.g., swales, ditches); and
3. Sedimentation for removing sediments that can fill in lakes, generate turbidity impairments, and concentrate other contaminants, such as PAHs.

Typical suspended sediment removal (and hence sediment accumulation) relies upon structural BMPs, such as wet ponds, engineered wetland treatment areas, and underground trapping devices. It should be noted that sediment removal is required as part of the expected operation and maintenance cycle for each of these sedimentation BMPs. In particular, wet extended detention ponds can usually remove up to 80% of the influent suspended solids (Minnesota Stormwater Steering Committee 2006). Sampling of the sediment for contaminants of potential concern, like PAHs, is necessary to plan for the appropriate beneficial reuse or disposal of sediments removed from stormwater ponds.

In 2000, the MPCA recommended that stormwater ponds be constructed with about 25 years of sediment storage (MPCA 2000). Recent experience for the stormwater ponds serving the Chain of Lakes in Minneapolis, MN suggests that more frequent (e.g., 5 – 8 year interval) pond excavations may be necessary (Hafner and Panzer 2005). In addition, more recent guidance in the Minnesota Stormwater Manual highly recommends that sediment be removed every 2 to 7 years from the forebay or after 50% of the total forebay capacity has been lost (Minnesota Stormwater Steering Committee 2006).

Aquatic vegetation planted around stormwater ponds not only simulates a natural system, but also serves as a biological filter to retain fine sediment and the contaminants bound to it. The combination of a pond and constructed wetland system usually provide greater storage capacity of stormwater and allow for a greater number of smaller particles, like clays, to settle out of stormwater. Wetland plants utilize phosphorus and nitrogen from the stormwater, resulting in fewer nutrients to downstream waters.

Although some contaminants may be able to biodegrade within stormwater ponds, hydrophobic organic contaminants like PAHs and PCBs are more persistent and will accumulate in the sediment. This sediment can be resuspended and flushed downstream during high runoff events or when the pond has filled up. These contaminants are of concern because local wildlife (e.g., ducks) are attracted to the stormwater ponds and use them as habitat. In addition, people may illegally or inadvertently use the stormwater ponds for recreation and be exposed to unhealthy concentrations of contaminants, depending on the duration and type of exposure and concentration of contaminants. Finally, reduced trapping of sediments and nutrients will cause additional loading to downstream waters, which will exacerbate efforts to retain and maintain water quality through Total Maximum Daily Load (TMDL) limits.

Use of Stormwater Ponds in Minnesota

Thousands of stormwater ponds are used throughout Minnesota. The MPCA has required stormwater ponds, or other BMPs, for newly constructed impervious cover since the early 1990s. The MPCA regulates the stormwater discharges of only 235 communities in Minnesota with oversight of ponds through the Municipal Separate Storm Sewer System (MS4) permit program of the National Pollutant Discharge Elimination System (NPDES). The locations of the MS4 permits on a statewide basis and in the Twin Cities metropolitan area are shown in Figures 2 and 3, respectively. The Minnesota Stormwater Manual provides guidance for the six required components of the MS4 permit process (Minnesota Stormwater Steering Committee 2006). Most other privately (e.g., homeowner association) and publicly owned stormwater ponds are unregulated.

Many of the stormwater ponds in Minnesota are over 15 years old and are filling up with sediment that must be removed to maintain the efficiency of these structures. Dredged sediment from stormwater ponds is usually used as a fill material or placed in a landfill. Recent studies have revealed that some of these stormwater ponds are accumulating high concentrations of PAHs. Municipalities like White Bear Lake, MN are grappling with how to pay for the disposal of these contaminated sediments and are looking to the MPCA for guidance (Appendix A). Some stormwater pond sediments have contaminant concentrations that prevent reuse or disposal by means other than at a high cost at one of Minnesota's limited number of lined landfills. Pavement dust and runoff from driveways and parking lots treated with coal tar-based sealcoats are emerging as important sources of these PAHs, some of which are probable carcinogens.

Limitations of this Report

It was beyond the scope of this report to estimate costs associated with:

- Developing an inventory of MS4 stormwater ponds in Minnesota;
- Monitoring stormwater pond sediments for contaminants of potential concern in the MS4 program;
- Implementing dredging and sediment disposal options for MS4 stormwater ponds; and
- Considering the aforementioned costs to businesses, homeowner associations, and other owners of private ponds that were built for the protection of water quality.

It was also beyond the scope of this document to discuss related issues beyond pond sediment, such as:

- Sediment quality of other BMPs, such as sump manholes and other devices;
- Potential contamination in underground infiltration devices that receive minimal pretreatment;
- Feasibility of whether overlying water in stormwater ponds could be used for local irrigation and whether doing so would result in an unacceptable accumulation of contaminants in the soil; and
- Whether asphalt roof shingles could pose a significant source of PAHs to stormwater ponds.

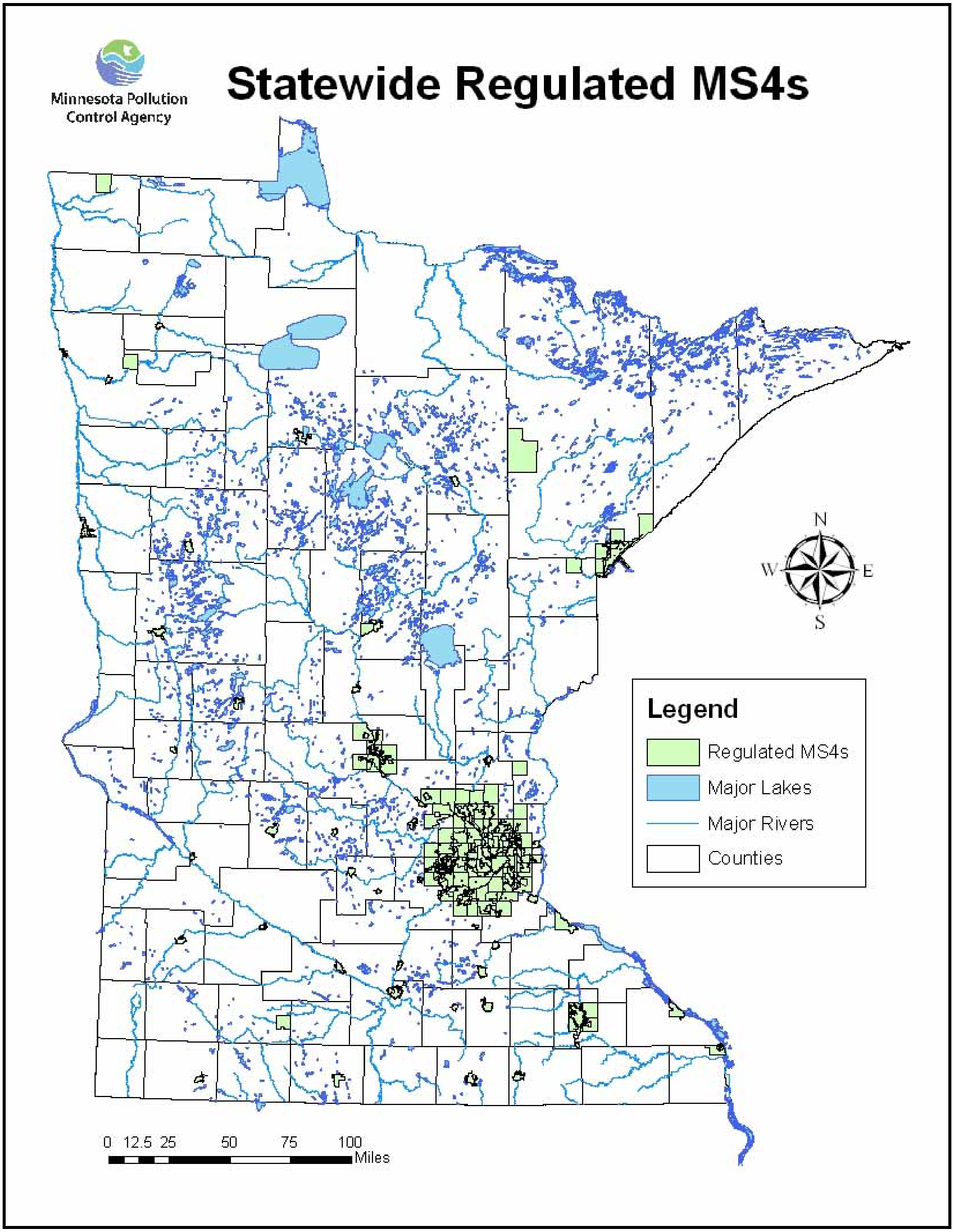


Figure 2. Location of regulated MS4 permits in Minnesota.

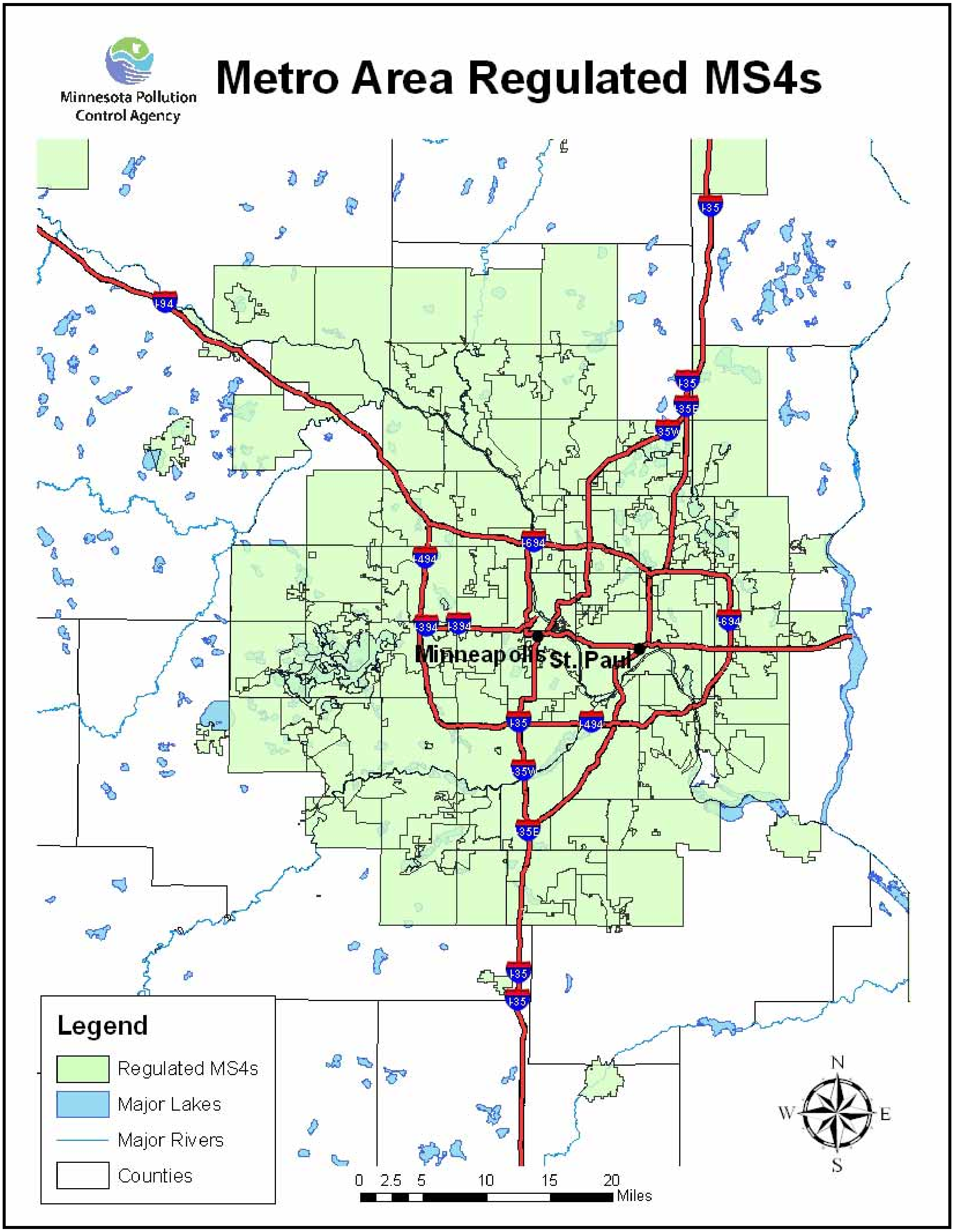


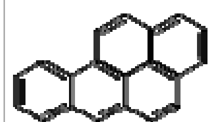
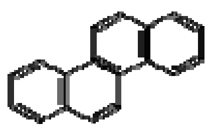
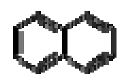
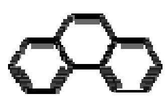
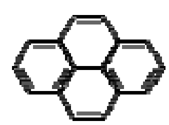
Figure 3. Location of regulated MS4 permits in the Minneapolis-St. Paul metropolitan area.

Environmental Chemistry and Toxicity of PAHs

Physical/Chemical Properties of PAHs

Polycyclic aromatic hydrocarbons are persistent organic pollutants comprised of hundreds of individual substances (Douben 2003). Composed of carbon and hydrogen, their structure includes two or more benzene rings (six-sided with three double bonds) and may contain other fused ring structures. These compounds usually occur as mixtures. Some commonly measured PAHs in sediments are provided in Table 1.

Table 1. Commonly Measured PAH Compounds in Sediments (from: http://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbons)

Chemical compound		**Chemical compound**	
Anthracene		Benzo[a]pyrene	
Chrysene		Naphthalene	
Phenanthrene		Pyrene	

PAHs are composed of either parent or alkylated compounds. Parent PAHs consist of only benzene rings fused together, such as the PAH compounds listed in Table 1. Alkylated PAHs have alkyl substitutions added to the fused ring structure. The PAHs most prevalent in environmental samples have two to six fused rings.

Physical and chemical characteristics of PAHs vary with molecular weight, which affects their distribution and fate in the environment. The general physical/chemical properties of PAHs include: high melting and boiling points, low vapor pressure, and very low water solubility (especially with increasing molecular mass; ATSDR 1995; Douben 2003). These properties make PAHs hydrophobic (i.e., avoid water) and lipophilic (i.e., accumulate in fat). Thus, these compounds tend to partition to organic carbon, fat in tissues, and particles in air, land, and water. Low molecular weight PAHs (LPAHs) like naphthalene and other 2 to 3 ring group PAHs may occur as a vapor and are more water soluble than the higher molecular weight PAHs (HPAHs) like pyrene and other 4 to 7 ring PAHs (Neff 1979). PAHs are stable molecules at ambient temperatures that can also volatilize, photolyze, oxidize, biodegrade, or accumulate in organisms (ATSDR 1995). The fate of PAHs in sediments is shown in Figure 4. PAHs in depositional sediment zones will eventually be permanently buried, whereas the active surface layer will be subject to resuspension through bioturbation, currents, wind-induced waves, and recreational and commercial boating activities. Bioturbation in stormwater pond sediments has been shown to increase vertical fluxes of contaminants in the sediment layer (Nogaro and Mermillod-Blondin 2009).

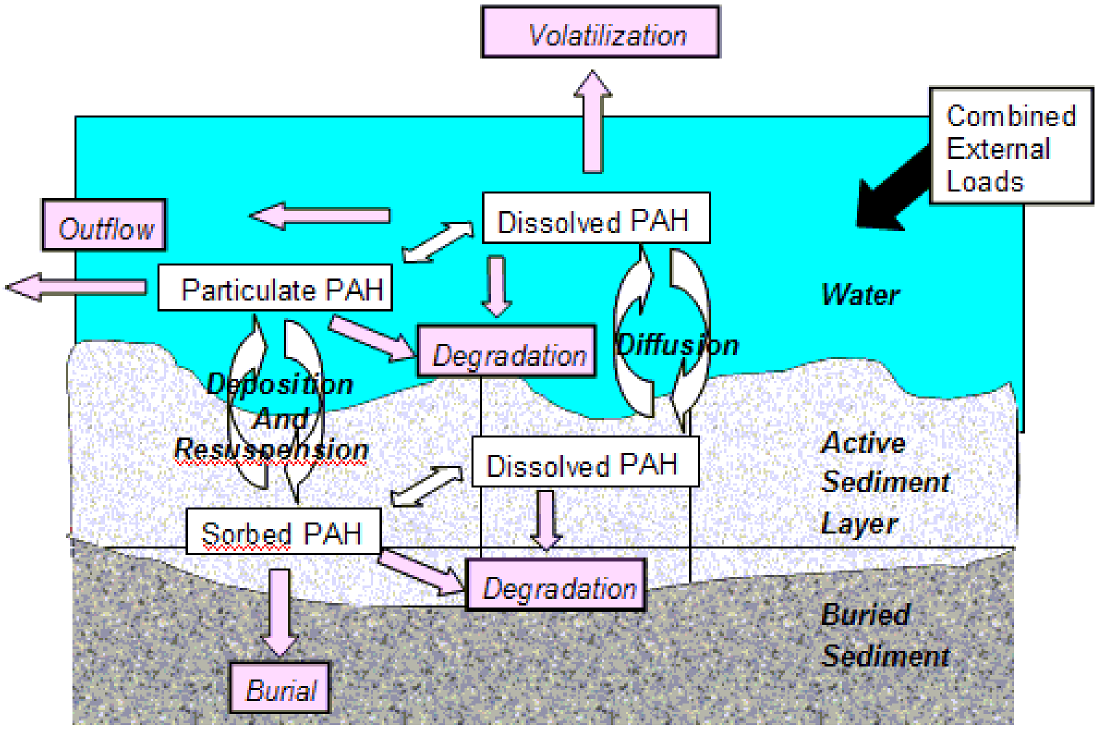


Figure 4. Fate of PAHs in sediments (Greenfield and Davis 2003).

An overview of the partitioning and bioavailability of PAHs in sediments and soils is provided by Burgess *et al*. (2003). The octanol – water partition coefficient (K_{ow}) is a good predictor of PAH partitioning that can be used to determine its behavior and bioavailability in the environment (Meador 2003). However, the partitioning of PAHs in sediment can be affected by soot carbon (i.e., black carbon), coal particles, and kerogen. Black carbon (i.e., soot and char from charcoal) is formed by the combustion of biomass and fuel, and it may end up in soil, sediment, and the air (Pignatello *et al*. 2006). Black carbon increases the sorption of hydrophobic organic chemicals like PAHs and PCBs. Black carbon, along with coal and kerogen, are collectively termed "carbonaceous geosorbents" (CG). The presence of CG can explain: 1) sorption to sediments being up to two orders of magnitude higher than expected on the basis of sorption to amorphous organic matter only, 2) low and variable biota-to-sediment accumulation factors (i.e., lower bioavailability than expected), and 3) limited potential for microbial degradation (Cornelissen *et al.* 2005). Consequently, PAHs and PCBs may partition less to pore water in sediments that contain soot, coal particles, and/or kerogen than would be expected with typical organic carbon partitioning.

Other studies have examined how the types of particles in sediment affect the partitioning of PAHs. A study of PAHs in sediment dredged from Milwaukee Harbor, WI showed that PAH sorption on coal-derived particles was associated with minimal biodegradation, slow release rates, and high desorption activation energies, while PAH sorption on clay/silt particles was associated with significant potential biodegradability, relatively fast release rates, and lower desorption activation energies (Talley *et al*. 2002). Although most of the PAHs in this study were associated with coal-derived particles, the PAHs on the clay/silt sediment fraction were more mobile and bioavailable and could contribute a greater proportion of risk to ecological receptors (Talley *et al*. 2002). In another study of sediments at three urban locations in the east coast (Harbor Point, NY), midwest (Milwaukee Harbor), and west coast (Hunters Point, CA), carbonaceous particles (primarily coal, coke, charcoal, pitch, cenospheres, and wood) were separated from the mineral fraction (primarily sand, silt, and clays), and the carbonaceous particles were found to contribute 5 - 7% of the total mass and 60 - 90% of the PCBs and PAHs (Ghosh *et al*. 2003). A recent study by Ghosh and Hawthorne (2010) provided the first report of equilibrium partitioning assessment of PAHs conducted at the sediment particle (sand, wood, coal/coke, and pitch) scale for sediments from manufactured gas plant sites; they found that source pitch particles may dominate PAH partitioning in these samples.

Laboratory analysis of the entire family of PAHs in environmental samples is not feasible, particularly since analytical standards are only available for a subsample of PAHs. PAHs must be extracted from the environmental matrix (e.g., sediment) and cleaned up of potential interferences before being quantified. PAHs are commonly measured by either high performance liquid chromatography (HPLC; EPA methods 610 or 8310) or gas chromatography/mass spectrometry (GC/MS) in the full scan mode (EPA method 8270) or GC/MS in selective ion monitoring (SIM) mode (EPA method 8270D; Mills 2008). Samples analyzed by HPLC to determine the list of 16 common parent PAHs can encounter matrix interferences, while samples analyzed by GC/MS can provide absolute identification of a larger number of PAH compounds; however, the detection limits may not be low enough for some samples (Mills 2008). Samples analyzed by GC/MS SIM can achieve lower detection limits, but these analyses are more expensive. Table 2 lists some commonly reported groups of PAHs in environmental samples.

In situ field screening of PAHs in sediments is available using laser induced fluorescence (LIF). In addition, LIF coupled with solid-phase microextraction (SPME) is being used for the *in situ* determination of PAHs in sediment pore water (Hawthorne *et al*. 2008) as a way to estimate impacts on aquatic life.

Ecological Effects from Exposure to Sediment-Related PAHs

Since PAHs preferentially adsorb to sediment, aquatic organisms and piscivorous wildlife that spend time in or near sediment are more likely to be exposed to these chemicals. The bioavailable fraction of PAHs in sediment and pore water is of concern when assessing risk to these ecological receptors. The age of the PAH-contaminated sediments can also affect bioavailability, with freshly contaminated sediments being more bioavailable than aged sediments (Alexander 2000; Volkering and Breure 2003). In addition, plant detritus may be an important sorbent for PAHs that can readily release PAHs into the water column or pore water (Rockne *et al*. 2002). Since PAHs occur in mixtures, display different mechanisms of toxicity, and are susceptible to transformation reactions, the joint action of PAHs in mixtures and with other contaminants have been the subject of much research (Altenburger *et al*. 2003).

PAHs are rapidly metabolized by fish, leading to little bioaccumulation (Lemaire *et al*. 1990). Thus, biomagnification of PAHs is not expected for food webs involving fish (Meador 2003). Fish exposed to PAH contamination have exhibited chronic effects, including: fin erosion, liver abnormalities, cataracts, skin tumors, and immune system impairments leading to increased susceptibility to disease (ATSDR 1995). In addition, PAHs may cause biochemical effects in fish through induction of mixed-function oxygenase enzymes (or cytochrome-P450), genetic effects through the formation of DNA adducts, potential reproductive toxicity, developmental effects to larval and juvenile fish, and potential behavioral effects (Akcha *et al*. 2003; Payne *et al*. 2003).

Benthic invertebrates exposed to sediment-related PAHs are susceptible to a number of detrimental effects, including: inhibited reproduction, delayed emergence, sediment avoidance, and mortality (ATSDR 1995). The ability to metabolize PAHs is highly variable in invertebrates (Meador 2003). Natural populations of benthic invertebrates in the St. Louis River Area of Concern, MN accumulated lower concentrations of HPAHs than lab exposed invertebrates (Thijssen 1997). Factors that affect PAH accumulation include: organism behavior, laboratory artifacts, organism size, and seasonal changes in physiology, behavior, and environmental inputs (Meador 2003). Food web transfer of PAHs may occur in some invertebrates that are not able to effectively metabolize these compounds (Meador 2003). Most information about PAH bioaccumulation is limited to parent compounds, but alkylated PAHs may be important, too (Meador 2003).

A nonspecific narcosis-like mode of action is the most important mechanism by which acute effects occur in benthic invertebrates (Van Brummelen *et al*. 1998). Narcosis results in the degradation of cell membranes. The U.S. EPA's narcosis model requires the measurement of 18 parent and 16 groups of alkyl PAHs (i.e., group of 34 PAHs) in sediments to calculate the number of PAH toxic units (TUs) available to benthic organisms

Table 2. List of Typical PAH Compounds Measured in Environmental Samples

PAH Compound Names	CAS Number	U.S. EPA Group B2, Probable Human Carcinogen (7 PAHs)[1]	ATSDR (17 PAHs)[2]	PAHs in Urban Runoff (USGS, WDNR, MPCA study; 18 PAHs)[3]	Probable or Possible Carcinogenic PAHs Adopted by MDH and MPCA (25 PAHs)[4]
Acenaphthene	83-32-9		x	x	
Acenaphthylene	208-96-8		x	x	
Anthracene	120-12-7		x	x	
Benz[a]anthracene	56-55-3	x	x	x	x
Benzo[a]pyrene	50-32-8	x	x	x	x
Chrysene	218-01-9	x	x	x	x
Benzo[b]fluoranthene	205-99-2	x	x	x	x
Benzo[e]pyrene	192-97-2		x		
Benzo[g,h,i]perylene	191-24-2		x	x	
Benzo[j]fluoranthene	205-82-3		x		x
Benzo[k]fluoranthene	207-08-9	x	x	x	x
Dibenz[a,h]anthracene	53-70-3	x	x	x	x
Fluoranthene	206-44-0		x	x	
Fluorine	86-73-7		x	x	
Indeno[1,2,3-cd]pyrene	193-39-5	x	x	x	x
Phenanthrene	85-01-8		x	x	
Pyrene	76165-23-6		x	x	
1-Methylnaphthalene	90-12-0			x	
2-Methylnaphthalene	91-57-6			x	
Naphthalene	91-20-3			x	
Dibenz[a,j]acridine	224-42-0				x
Dibenz[a,h]acridine	226-36-8				x
7H-Dibenzo[c,g]carbazole	194-59-2				x
Dibenzo[a,e]pyrene	192-65-4				x
Dibenzo[a,h]pyrene	189-64-0				x
Dibenzo[a,i]pyrene	189-55-9				x
Dibenzo[a,l]pyrene	191-30-0				x
7,12-Dimethylbenzanthracene	57-97-6				x
1,6-Dinitropyrene	42397-64-8				x
1,8-Dinitropyrene	42397-65-9				x
3-Methylcholanthrene	56-49-5				x
5-Methylchrysene	3697-24-3				x
5-Nitroacenaphthene	602-87-9				x
1-Nitropyrene	5522-43-0				x

Table 2. Continued

PAH Compound Names	CAS Number	U.S. EPA Group B2, Probable Human Carcinogen (7 PAHs)[1]	ATSDR (17 PAHs)[2]	PAHs in Urban Runoff (USGS, WDNR, MPCA study; 18 PAHs)[3]	Probable or Possible Carcinogenic PAHs Adopted by MDH and MPCA (25 PAHs)[4]
4-Nitropyrene	57835-92-4				x
6-Nitrochrysene	7496-02-8				x
2-Nitrofluorene	607-57-8				x

[1] U.S. EPA's Integrated Risk Information System (IRIS) has classified seven PAHs as Group B2, probable human carcinogens (http://cfpub.epa.gov/ncea/iris/index.cfm).

[2] Agency for Toxic Substances and Disease Registry (ATSDR 1995). These 17 PAHs were chosen to be included in this profile because: (1) more information is available on these compounds than on the others; (2) they are suspected to be more harmful than some of the other compounds, and they exhibit harmful effects that are representative of PAHs; (3) there is a greater chance that humans will be exposed to these PAHs than to the others; and (4) of all the PAHs analyzed, these were the PAHs identified at the highest concentrations at National Priorities List (NPL) hazardous waste sites.

[3] Selbig and Bannerman (2009) for a study by the USGS and Wisconsin Department of Natural Resources (WDNR) with partnership from the MPCA. This study was conducted to characterize PAH concentrations in urban runoff from different source areas and land uses in Wisconsin.

[4] Minnesota Department of Health (MDH 2004).

(USEPA 2003). Sediment concentrations of the 34 PAHs are used along with their expected sediment/water/lipid partitioning behavior to calculate a hazard quotient, referred to as a TU, which is used as a benchmark for predicting the toxicity of PAHs to benthic invertebrates (Hawthorne *et al*. 2006). If data for the 34 PAHs are not available, the U.S. EPA proposes estimating the risk by multiplying the TU for 13 parent PAHs by 11.5 (95% confidence interval) based on data from 488 sediments (USEPA 2003). Hawthorne *et al*. (2006) suggest this estimate is overly conservative for PAHs from pyrogenic manufactured gas plant (MGP) processes based on the analysis of 45 sediments from six sites; they demonstrated that a factor of 4.2 (rather than 11.5) is sufficient to estimate total TUs within a 95% confidence level for MGP sites.

Researchers in Austin, TX investigated whether benthic invertebrate communities were adversely affected in streams downstream of sealcoated parking lots (Scoggins *et al*. 2007). They found significant decreases in species richness, intolerant taxa, Diptera taxa, and density in downstream pool and riffle habitats compared to upstream reference sites. The differences between upstream and downstream concentrations of total PAHs ranged from 3.9 to 32 mg/kg dry weight. The higher PAH TUs in downstream pool sites explained the observed decreases in taxon richness and density compared to upstream reference sites. A follow-up study by Bryer *et al*. (2009) looked at whether dried coal tar pavement sealant flake could alter the macroinvertebrate communities native to streams in Austin, TX by using a controlled outdoor laboratory experiment. After a 24-day exposure period, they found community differences in abundance ($P = 0.00004$) and richness ($P<0.0001$) between treatments containing a control and low, medium, and high concentrations of total PAHs (based on the sum of the EPA's 16 priority PAHs) at concentrations of 0.1, 7.5, 18.4, and 300 mg/kg, respectively. While abundance and number of taxa was higher than the control in the low treatment, these indicators were depressed in the highest PAH concentration. These indicators were not different from the control for the medium treatment. Bryer *et al*. (2009) concluded that coal tar pavement sealcoats contain bioavailable PAHs that may harm aquatic habitats.

Certain PAHs can act as photosensitizing agents in the presence of solar ultraviolet (UV) radiation. Ankley *et al*. (2003) provided a literature review on assessing risks from photoactivated toxicity of PAHs to aquatic organisms, and they noted a number of studies showing that UV radiation can greatly increase the toxicity of PAHs in a broad phylogenetic spectrum of aquatic organisms. Stormwater runoff samples contaminated with PAHs showed an increase in chronic toxicity to the reproduction of the cladoceran, *Ceriodaphnia dubia*, when exposed to UV wavelengths as compared to *C. dubia* not exposed to UV wavelengths (Ireland *et al*. 1996). Field collected amphipods (scuds) from the lower St. Louis River and Duluth Harbor, MN were exposed to UV light, and the results indicated that organisms residing in PAH-contaminated environments accumulated PAH concentrations sufficient to be at risk for photoactivated toxicity (Diamond *et al*. 2003). In a different laboratory experiment, the spectral characteristics of UV light were shown to be an important factor in predicting photoinduced sediment toxicity from exposure to PAH compounds (Diamond *et al*. 2000).

Kanaly and Harayama (2000) have reviewed the biodegradation of HPAHs by bacteria, for which a number of HPAH-degrading strains have been isolated and characterized. A literature review on biodegradation of PAHs and general aspects of bioavailability was prepared by Volkering and Breure (2003). Naturally occurring *Mycobacterium* has been shown to degrade pyrene and appears to be able to degrade recalcitrant HPAHs in Lake Erie sediments (DeBruyn *et al*. 2009). Sorption to humic acids appears to enhance the biodegradation of PAH compounds by bacteria by supplementing the diffusive uptake from the freely dissolved phase (Smith *et al*. 2009). Information on biodegradation is important for studying the fate of PAHs in environmental samples and for developing favorable conditions for bioremediation of PAH-contaminated soils and sediments.

Plants display a wide range of responses to PAHs, and plants are more sensitive to a mixture of PAHs and metals (Greenberg 2003). Since some plants can take up PAHs rapidly and with high bioconcentration factors, some plant species, like hybrid poplar trees, are showing promise for phytoremediation of PAHs in soils; however, a combination of remediation techniques may be needed to reduce PAH concentrations to acceptable concentrations (Greenberg 2003). For other plants, uptake of PAHs is limited by solubility. Watts *et al.* (2006; 2008) investigated PAH uptake in salt marsh plants and found almost no uptake in the foliage, but high concentrations of PAHs were observed in roots and also in leaves exposed to sediment splashing.

Human Health Risks from Exposure to Sediment-Related PAHs

The most complete human health pathways by which children and adults can be exposed to sediment-related PAHs include: ingestion of aquatic invertebrates that haven't fully metabolized PAHs (e.g., clams), incidental ingestion of water while swimming or playing in contaminated areas, and dermal exposure from contaminated mud or water while wading or swimming in the water. Human health risks depend on: 1) the toxicological properties of the PAHs and other co-occurring contaminants, 2) the manner in which the person contacts the chemical (i.e., exposure pathway), 3) the concentrations of the contaminants; 4) how often the exposure occurs, 5) how long the exposure occurs, and 6) how much of the chemical is absorbed into the body during each exposure event (Villanacci and Beauchamp 2003). In addition, other factors for sensitive groups (e.g., children, elderly, and those people with compromised immune systems) may need to be taken into consideration. Since PAHs are ubiquitous in the environment, people are exposed to them every day through other pathways; for example, exposure to PAHs via inhalation is estimated to range from 0.02 - 3 µg/day, and smokers are exposed to even more PAHs from inhaling cigarette smoke (ATSDR 1995). The intake of carcinogenic PAHs resulting from consumption of mostly unprocessed grains and cooked meat in the average American diet has been estimated to range from 1 - 5 µg/day, with higher amounts for individuals who consume large amounts of cooked meat (ATSDR 1995).

The U.S. EPA's IRIS database has classified the following seven PAH compounds as probable human carcinogens (Group B2), indicating sufficient evidence of carcinogenesis in animals, but inadequate evidence in humans: benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene (http://cfpub.epa.gov/ncea/iris/index.cfm). PAHs known for their carcinogenic, mutagenic, and teratogenic properties include: benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[ghi]perylene, coronene, dibenz[a,h]anthracene (C_{20} H_{14}), indeno[1,2,3-cd]pyrene ($C_{22}H_{12}$) and ovalene (Luch 2005).

PAHs can cause detrimental noncancer effects to humans due to acute or chronic exposures. The U.S. EPA has found PAHs similar to benzo[a]pyrene to cause red blood cell damage (leading to anemia) and suppression of immune system function at acute concentrations above the Maximum Contaminant Level (MCL) of 0.0002 mg/L in drinking water (USEPA 2006). Benzo[a]pyrene has the potential to cause developmental and reproductive effects at chronic exposures above the MCL (USEPA 2006). However, these results are based on rodent studies and may not occur in humans at environmental exposure concentrations (Muller 2002).

Because benzo[a]pyrene (B[a]P) is frequently detected in environmental samples at relatively high concentrations and has a high level of toxicity compared to other PAH compounds, it is often selected as a surrogate for other PAH compounds (Muller 2002). Benzo[a]pyrene is the only PAH compound for which a cancer potency factor has been developed, and the potency factor for B[a]P is used as a basis for determining relative carcinogenic potential for the other carcinogenic PAHs. As such, the U.S. EPA developed toxicity equivalence factors (TEFs) to rank the relative carcinogenic potential of other PAHs to B[a]P.

The TEFs can be used for estimating the relative carcinogenicity of an environmental mixture with a known distribution of PAHs. The B[a]P equivalency is calculated by summing the products of each carcinogenic PAH concentration and its corresponding potency factor (Muller 2002). The number of PAHs involved in the calculation may vary depending on the study. The B[a]P equivalency factors used by the Minnesota Department of Health (MDH) and MPCA are provided on the MDH web site at: http://www.health.state.mn.us/divs/eh/risk/guidance/pahmemo.html.

Biomarkers are used to help determine the nature and magnitude of human health risks resulting from exposure to PAHs. Franco *et al*. (2008) provide a review of PAH biomarkers for human health risk assessment. Recent validation studies indicate urinary 1-hydroxy-pyrene has been validated for monitoring exposure and PAH-DNA adducts in lymphocytes can be used as a marker of effective dose (Franco *et al*. 2008). Biomarkers that are still in the development phase, but which show promise, include cytogenetic markers of early effect, evaluation of frequency of chromosomal aberrations, and micronucleus induction (Franco *et al*. 2008).

Although stormwater ponds may be posted with signs for people to keep out of the water, people may not always comply with this signage. As an example of how human health risk may be assessed due to exposure to sediment-derived PAHs, the scenario at Barton Springs Pool in Austin, TX will be described. This pool was contaminated with PAHs from runoff from parking lots treated with coal tar-based sealcoats. The Agency for Toxic Substances and Disease Registry (ATSDR) supported a human health consultation for this pool that was based on 20 PAH compounds and seven other contaminants of concern (Villanacci and Beauchamp 2003). This consultation concluded that swimming and playing in Barton Springs Pool did not pose a public health hazard, even with using a conservative exposure scenario with the following assumptions: an individual would ingest 50 mL of pool water per hour, three hours per day, seven days per week, and 52 weeks per year, for 70 years (Villanacci and Beauchamp 2003). Although there was not a significant risk at this site, that does not preclude potential human health risks at other sites that may have higher concentrations of PAHs in the sediments or other complete human health exposure pathways (e.g., consumption of contaminated crayfish).

Although not a direct sediment issue, coal tar-based sealcoat has recently emerged as a previously unrecognized source of PAHs to settled house dust. A study by Mahler and her collaborators (Mahler *et al*. 2010) determined that total PAHs in settled house dust from apartments in Austin, TX with coal tar-based sealed parking lots were 25 times higher than that in settled house dust from apartments with parking lots with other pavement surface types. Additional information about this study is provided in the section of this report on “Environmental Fate and Transport of PAHs Associated with Sealcoat Products.” This study concluded that nondietary exposure to probable carcinogenic (B2) PAHs in settled house dust might be the most important exposure pathway for children living in residences with coal tar sealcoated parking lots or driveways (Mahler *et al*. 2010).

Screening Benchmarks to Assess Sediment/Soil Quality for PAHs

Sediment Quality Targets Used in Minnesota

Numerical sediment quality targets (SQTs) were adopted for use in the St. Louis River Area of Concern (AOC) in northeastern Minnesota to protect benthic invertebrates (Crane *et al*. 2000, 2002; Crane and MacDonald 2003). The SQTs are a type of sediment quality guideline (SQG) that provide useful tools for making sediment management decisions, especially when considered as part of a weight-of-evidence approach that includes other sediment quality indicators, such as geochemical characteristics (e.g., particle size), sediment toxicity, benthic invertebrate community structure, and tissue residue chemistry (Crane *et al*. 2000, 2002; Crane and MacDonald 2003). Two types of narrative SQTs were established by the MPCA and its collaborators (Crane *et al*. 2000; Appendix B).

- The Level I SQTs are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms (i.e., benthic invertebrates) are unlikely to be observed.
- The Level II SQTs are intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are likely to be observed.

The narrative objectives for both levels of SQTs do not address the potential for bioaccumulation nor the associated effects on those species that consume aquatic organisms (i.e., wildlife and humans; Crane *et al*. 2000). The Level I and Level II SQTs can be used elsewhere in Minnesota in depositional deposits of sediments found in lakes, ponds, wetlands, low gradient rivers and streams, as well as ports and harbors (Crane and MacDonald 2003). Thus, these SQTs can be used as benchmark values for making comparisons to surficial sediment chemistry measurements throughout the State of Minnesota. The SQTs are most applicable to the issue of stormwater pond sediments in terms of beneficially reusing the dredged material in aquatic habitats for beach nourishment and habitat creation (such as creating islands from the dredged material).

Inclusion of PAH compounds in the SQTs

Only the 13 priority PAHs are included in the calculation of total PAHs for comparison to the Level I and Level II SQTs for total PAHs (Crane and Hennes 2007; Appendix B). These priority PAHs include seven LPAHs and six HPAHs.

- The individual compounds included in the LPAH total (if measured in the study) are:
    - Acenaphthene;
    - Acenaphthylene;
    - Anthracene;
    - Fluorine;
    - 2-Methylnaphthalene;
    - Naphthalene; and
    - Phenanthrene.
- The individual compounds included in the HPAH total (if measured in the study) are:
    - Benz[a]anthracene;
    - Benzo[a]pyrene;
    - Chrysene;
    - Dibenz[a,h]anthracene;
    - Fluoranthene; and
    - Pyrene.

If users want to develop a more conservative estimate of total PAHs at a site to compare to the Level I and Level II SQTs, they may include additional PAHs (e.g., benzo[b&j]fluoranthene) in the calculation of total PAHs. However, they should add a subscript of the number of PAHs used in the calculation (e.g., total PAH_{16})

to clarify their intent. For further guidance on the calculation of total PAHs, contact either Judy Crane [651-757-2293 (voice); judy.crane@state.mn.us] or Steve Hennes [651-757-2426 (voice); steven.hennes@pca.state.mn.us].

Use of mean probable effect concentration quotients

Comparisons of individual chemical concentrations to the corresponding Level I and Level II SQTs can be used to determine contaminants of concern at a site. Sediments are frequently contaminated with complex mixtures of chemicals, and the composition of the chemical mixture can vary considerably within a study area or site (Long *et al.* 2006). Mean probable effect concentration quotients (PEC-Qs) provide a sediment assessment tool that distills data from a mixture of contaminants (i.e., certain metals, total PAHs, and/or total PCBs) into one unitless index. Thus, the mean PEC-Qs provide a way to compare sediment quality over time and space (Long *et al*. 2006). The mean PEC-Qs also provide a straightforward, effects-based numerical index of the relative degree of chemical contamination of sediment samples (Crane and Hennes 2007). A number of sediment studies in different geographic areas of North America demonstrate that both the incidence and magnitude of sediment toxicity in laboratory tests, and the incidence of impairment to natural benthic communities, increases incrementally with increasing mean SQG quotients (Long *et al*. 2006). Crane and Hennes (2007) provide guidance on how to calculate mean PEC-Qs.

Frequently asked questions about SQTs in relation to PAHs

The following questions and responses are from the MPCA report on “Guidance for the Use and Application of Sediment Quality Targets for the Protection of Sediment-dwelling Organisms in Minnesota” (Crane and Hennes 2007). These issues are directly applicable to PAH-contaminated stormwater pond sediments.

1. **Should the SQTs for nonionic organic compounds, such as PAHs, be normalized to total organic carbon (TOC) if TOC data are available?**
   Answer: No, the SQTs are expressed on a bulk sediment dry weight basis, and should not be adjusted or normalized for organic carbon. The consensus-based SQGs and Canadian SQGs, which are the basis for all but one of the SQTs, are expressed as dry weight concentrations in the original publications (CCME 1999; MacDonald *et al.* 2000). In theory, normalization to organic carbon to adjust for potential decreased bioavailability is appropriate. However, the results of previous studies have shown that dry weight-normalized SQGs predicted sediment toxicity as well, or better, than organic carbon-normalized SQGs in field-collected sediments (Barrick *et al*. 1988; Long *et al.* 1995; Ingersoll *et al*. 1996; USEPA 1996; MacDonald 1997). Sorption to sediments is a complex and variable phenomenon, which cannot be captured by simple TOC normalization.

2. **Can the Level I and Level II SQTs be used for the disposal of dredged material on land?**
   Answer: No. The Level I and Level II SQTs are not designed to be protective of terrestrial invertebrates. Instead, refer to the MPCA’s document on “Managing Dredged Materials in the State of Minnesota” (Stollenwerk *et al*. 2009) for guidance on using soil reference values (SRVs) to assess the quality of the dredged material for potential land disposal.

3. **Can the Level I and Level II SQTs be used to assess sediment quality for the open water disposal of dredged material?**
   Answer: The MPCA does not allow for deep water disposal of dredged material, except for the creation of beneficial uses such as beach nourishment and habitat creation (Stollenwerk *et al*. 2009). Under those circumstances, the SQTs could be used to screen the quality of the sediment to be used for beneficial uses within the water.

4. **Are there situations where the SQTs may not be adequately protective?**
   Answer: Yes. For example, enhanced toxicity can occur if PAH-exposed organisms are simultaneously exposed to UV light (USEPA 2003), which is not factored into the SQTs. In environments where significant sunlight penetrates to the sediment and benthic organisms are exposed to UV light, the SQTs may be under protective.

5. **Are there conditions which may result in the SQTs being overly protective?**

Answer: Yes, PAHs and PCBs may partition less to interstitial water in sediments that contain soot, coal particles, and/or kerogen than would be expected with typical organic carbon partitioning. This could cause the SQTs to be over protective. These conditions cannot be assumed, but need to be evaluated on a site-specific basis.

Reference to SQTs in the MPCA's Stormwater Manual

The MPCA's Stormwater Manual (Minnesota Stormwater Steering Committee 2006) refers to the SQTs as the state benchmark values for making comparisons to surficial sediment chemistry measurements. In addition, it encourages anyone interested in removing sediments from a BMP structure (e.g., stormwater ponds, pre-treatment supplements such as forebays and proprietary chambers, and non-clogging catch-basin inserts) that is not knowledgeable about the character of the material being removed to contact the MPCA via its Contaminated Sediment Web page (http://www.pca.state.mn.us/water/sediments/index.html). This manual also refers users to this web site for guidance on sampling suspected contaminated sediment from BMPs.

Soil Reference Values for PAHs

The MPCA's manual on "Managing Dredged Materials in the State of Minnesota" (Stollenwerk *et al.* 2009), provides guidance on the disposition of dredged material depending on comparison of contaminant concentrations (e.g., PAHs, metals) to the MPCA's Soil Reference Values (SRVs). The SRVs are soil contaminant concentrations above which an unacceptable risk to human health is predicted (MPCA 1999). The Tier 1 SRVs are provided at the following web link: http://www.pca.state.mn.us/publications/risk-tier1srv.xls, whereas the Tier 2 SRVs are provided at: http://www.pca.state.mn.us/publications/risk-tier2srv.xls. A compilation of the SRVs for PAHs are also listed in Appendix C.

Benzo[a]pyrene (B[a]P) equivalents are calculated for carcinogenic PAH SRVs per MDH guidance on PAHs at http://www.health.state.mn.us/divs/eh/risk/guidance/pahmemo.html and the MPCA's SRV spreadsheet at http://www.pca.state.mn.us/cleanup/riskbasedoc.html#pathway.

The remainder of this section on SRVs has been adapted from Stollenwerk *et al*. (2009).

Dredged Material is categorized into three Management Levels:

- Level 1;
- Level 2; and
- Level 3.

Level 1 Dredged Material is suitable for use or reuse on properties with a residential or recreational use category. Level 1 Dredged Material is characterized as being at or below analyte concentrations for all of the SRVs listed in the Level 1 SRV column of Table 5 from Stollenwerk *et al*. (2009), for which the PAH SRVs are provided in Appendix C.

The SRVs incorporate the most common human exposure pathways (ingestion, dermal contact, and inhalation of contaminants volatilized from soil in outdoor air) using generic exposure assumptions. The Level 1 (i.e., Tier 1) SRVs generally use a chronic residential exposure scenario, but are also protective of acute health effects in young children when acute toxicological data are available.

For dredged materials, the Level 1 SRV limits are the most restrictive.

Note: Exposure pathways in an agricultural land use setting have not been evaluated, and it is therefore not an appropriate land use category for comparison to SRVs.

Level 2 Dredged Material is suitable for use or reuse on properties with an industrial use category. Level 2 Dredged Material is characterized as being at or below analyte concentrations for all of the SRVs listed in the Level 2 (i.e., Tier 2) SRV column of Table 5 from Stollenwerk *et al*. (2009), for which the PAH SRVs are provided in Appendix C.

The Level 2 SRVs use an industrial exposure scenario based on average working adults according to a typical industrial site use. Level 2 SRVs are less restrictive than the Level 1 SRVs.

Level 3 Dredged Material is characterized as having significant contamination, as demonstrated by one or more analyte concentrations being greater than the Level 2 SRV column of Table 5 from Stollenwerk et al. (2009). Level 3 Dredged Material is considered to be significantly contaminated and must be managed specifically for the contaminants present.

In some cases, a Level 3 Dredged Material may have concentrations of contaminants at levels subject to regulation under the Resource Conservation and Recovery Act (RCRA) and/or the Toxic Substances Control Act (TSCA), if PCB concentrations in sediment are 50 mg/kg dry wt. or greater. In these cases, significant additional regulation applies, and disposal of the waste is strictly regulated.

Larger projects may produce dredge materials that can be segmented into areas with dredged materials that are distinctly different from each other. Subsets of dredged material may be managed differently from each other, depending on the Management Level applicable to each discreet subset. If subsets of Management Levels exist within the project, dredged material may be managed separately by levels (i.e., each subset of dredged material is managed at the relevant Management Level; managed at the most restrictive Management Level, if separation and management by subset is not feasible or desired; or, managed at the most restrictive Management Level if subsets from a given project or multiple projects, such as at a use/reuse staging area, are co-mingled prior to disposal).

Sources of PAHs to Waterways

Source Categories of PAHs

Polycyclic aromatic hydrocarbons are found naturally in coal and petroleum products and can be formed through the incomplete combustion of organic material. Boehm (2006) provided a thorough literature review of sources of PAHs to the environment, and sources of background PAHs to sediments are described in sediment guidance prepared for the U.S. Navy (Battelle Memorial Institute *et al.* 2003). The main sources of PAHs in sediments are due to petrogenic and pyrogenic processes, and to a lesser extent to diagenetic sources (Table 3).

Table 3. Source Categories of PAHs in Sediments (adapted from Battelle Memorial Institute *et al*. 2003)

PAH Category	**Origin**
Petrogenic	Formed by the geochemical alteration of organic matter at moderate temperature (50-150°C) and pressure over geologic time scales.
Pyrogenic	Generated when fuels and other organic matter are incompletely or inefficiently combusted or pyrolyzed at moderate to high temperatures (>400°C) over very short time intervals.
Diagenetic	Generated by either modern biological processes or by diagenetic processes (e.g., oxidation of microbial- or plant-derived compounds) in recent sediments. Usually account for part of the mass of PAHs in sediment cores associated with preindustrialization.

Anthropogenic sources make up the majority of PAHs in most environments (Battelle Memorial Institute *et al.* 2003; Mahler *et al.* 2005). Anthropogenic releases include petrogenic sources, such as releases of petroleum products like tire particles, deteriorating asphalt or asphalt sealant, coal storage piles, gasoline, and oil spills (ATSDR 1995; Curran *et al.* 2000; Mahler *et al.* 2005). Pyrogenic sources, such as gasoline combustion and exhaust, creosote treated lumber, combustion of wood, oil, and coal, and the production of coal tar, coke, and asphalt also release PAHs to the environment (Takada *et al.* 1990; Rogge *et al.* 1993; Simon and Sobieraj 2006). Important natural pyrogenic sources of PAHs include: forest fires, grass fires, and volcanoes. Diagenetic PAHs are derived from biogenic precursors, like plant terpenes, and include compounds like retene, perylene, and derivatives of phenanthrene and chrysene (Hites *et al.* 1980; Meyer and Ishiwatari 1993; Stillman *et al*. 1998). The pyrogenic parent PAHs are ubiquitous in the environment, whereas petrogenic alkylated PAHs are more likely to be due to point sources like oil spills or refineries (Burgess *et al*. 2003).

Contaminant transport pathways include atmospheric deposition and stormwater runoff from multiple sources such as roads, rooftops, parking lots, and surfaces of buildings and windows. Centralized power generated from fossil fuels or biofuels emit PAHs that are typically released via tall stacks that aid in pollutant dispersion over wider areas.

Urban Background Sources of PAHs to Sediment

Sediments from urban waterways have an "urban background" signature from a variety of nonpoint sources of PAHs which may confound the interpretation of point sources of PAHs to these waterways (Figure 5). Common point sources of PAHs include direct or indirect discharges from petroleum terminals, shipyards, aluminum smelting, manufactured gas production plants, tar distillation plants, rail yards, loading/unloading facilities, and spilled or seeped petroleum or coal- or oil-derived tars and their associated distillation products (e.g., creosote; Battelle Memorial Institute *et al.* 2003). In Minnesota, a number of sites that were contaminated with PAHs by past industrial releases are in the process of being remediated via State and Federal Superfund, RCRA, or related programs.

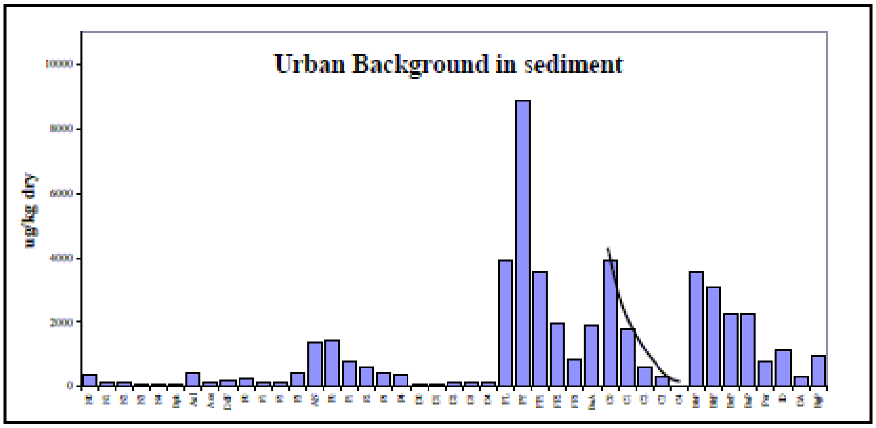


Figure 5. Histogram of typical urban background PAHs in sediment, with the highest concentrations corresponding to pyrogenic PAH compounds (Battelle Memorial Institute *et al*. 2003).

Stormwater runoff appears to be the largest source of PAHs to urban sediments (Battelle Memorial Institute *et al*. 2003). Stormwater runoff usually contains the following types of PAHs:

- Urban dust/soot particles containing combustion-related (i.e., pyrogenic) PAHs, primarily from the incomplete combustion of fuel within car and truck engines, especially diesel-based engines.
- Used lubricating oils (i.e., petrogenic PAHs), primarily from oil drippings from cars and trucks onto roadways, driveways, and parking lots.
- Waste oil and petroleum products (i.e., petrogenic PAHs) that are illegally or unintentionally discharged into a city's storm sewer system (Battelle Memorial Institute *et al*. 2003).

As will be further discussed in this report, pavement dust and runoff from coal tar-based sealcoats are emerging as important sources of PAHs to urban waterways (Mahler *et al*. 2005; Van Metre *et al*. 2008; Van Metre and Mahler 2009). These sealcoats are applied to driveways and parking lots, particularly in the central, southern, and eastern U.S.

Urban runoff and urban sediments are dominated by pyrogenic PAHs (Figure 5). The most abundant PAHs are HPAHs with 4- to 6-rings, particularly the fluoranthene and pyrene isomers. Of the LPAHs (i.e., 2- and 3-rings), the most abundant compounds in urban sediments are the anthracene and phenanthrene isomers (Battelle Memorial Institute *et al*. 2003).

Dibenzothiophene, which can represent a tire oxidation product, can be used as an indicator of traffic sources of PAHs (Van Dolah *et al*. 2005). In addition, changes in the composition of naturally occurring perylene in sediments can be indicative of pyrogenic sources of PAHs through urban contamination. As pyrogenic sources of PAHs are discharged into pristine areas, the percent perylene contribution that dominates under natural conditions may become only a small part of the total PAH profile. An evaluation of PAH runoff from highways into estuarine wetlands of South Carolina showed the percentages of perylene were low, ranging from 0 - 18.4% (mean = 10.9%), which corresponded to ranges of perylene measured in highly urban environments (Kuklick *et al*. 1997 as cited in Van Dolah *et al*. 2005).

PAH Forensics

PAH forensic (i.e., fingerprinting) techniques use ratios of varying kinds of petrogenic and pyrogenic PAHs to identify sources. This technique is especially useful for identifying potentially responsible parties at contaminated sediment sites. A list of PAHs that are commonly used to distinguish PAH sources is provided in Table 4. Boehm (2006) and Neff *et al*. (2005) have provided technical reviews of PAH source ratios, of which Tables 5 and 6 are provided from these sources, respectively. Guidance prepared for the U.S. Navy provided a useful appendix on "Chemical Fingerprinting of PAHs in Sediments—Recognizing the Contribution of Urban

Table 4. Inventory of PAH Compounds Commonly Used to Determine PAH Sources (Battelle Memorial Institute *et al*. 2003)

Analyte/Analyte Group	Ring #	Analyte/Analyte Group	Ring #
Naphthalene*	2	C3-dibenzothiophenes	3
C1-naphthalenes	2	C4-dibenzothiophenes	3
C2-naphthalenes	2	Fluoranthene*	4
C3-naphthalenes	2	Pyrene*	4
C4-naphthalenes	2	C1-fluoranthenes/pyrenes	4
Biphenyl	2	C2-fluoranthenes/pyrenes	4
Acenaphthylene*	3	C3-fluoranthenes/pyrenes	4
Acenaphthene*	3	Benz[a]anthracene*	4
Dibenzofuran	3	Chrysene*	4
Fluorene*	3	C1-chrysenes	4
C1-fluorenes	3	C2-chrysenes	4
C2-fluorenes	3	C3-chrysenes	4
C3-fluorenes	3	C4-chrysenes	4
Anthracene*	3	Benzo[b]fluoranthene*	5
Phenanthrene*	3	Benzo[k]fluoranthene*	5
C1-phenanthrenes/anthracenes	3	Benzo[e]pyrene	5
C2- phenanthrenes/anthracenes	3	Benzo[a]pyrene*	5
C3- phenanthrenes/anthracenes	3	Perylene	5
C4- phenanthrenes/anthracenes	3	Indeno[1,2,3-c,d]pyrene*	6
Dibenzothiophene	3	Dibenz[a,h]anthracene*	5
C1-dibenzothiophenes	3	Benzo[g,h,i]perylene	6
C2-dibenzothiophenes	3		

* Priority pollutant PAH.

Background" (Battelle Memorial Institute *et al*. 2003). The most important factors controlling PAH ratios relate to dry precipitation, surface-to-air diffusion, degradation in air and water, and exchange between water and sediment (Zhang *et al*. 2005). Zhang *et al*. (2005) have used a fugacity model to help quantify the differences in transport of individual PAH compounds and to improve the ability to identify sources of PAH contamination using PAH ratios.

PAH ratios work best at sites dominated by a single source. However, most environmental sediment samples have multiple sources of PAHs for which there may be varying rates of weathering of PAH compounds. Weathering occurs primarily through a combination of evaporation/volatilization processes, degradation by microorganisms, and dissolution into water (Battelle Memorial Institute *et al*. 2003). Weathering causes the following key changes to the PAH signature:

- Concentrations of LPAHs (i.e., 2- and 3-ring) PAHs are reduced, resulting in an increase in the proportion of 4- to 6-ring PAHs; and
- Concentrations of nonalkylated PAHs are reduced, resulting in an increase in the proportion of alkylated PAHs (Battelle Memorial Institute *et al*. 2003).

The use of a variety of source ratios and cross plots provided the best interpretation of PAH sources in the Fraser River Basin, British Columbia (Yunker *et al*. 2002). The amount of scatter in PAH ratio plots provide further information about PAH sources. Plots with a random scatter pattern are often indicative of equal weighting of multiple sources of PAHs, whereas less variation in the ratios may indicate only one or two sources dominate (Yunker *et al*. 2002).

Table 5. Diagnostic PAH Source Ratios [adapted from Boehm (2006) for which the references are available]

Diagnostic Ratio	Application	Reference
FFPI	Petrogenic/pyrogenic PAH allocation	Boehm and Farrington (1984)
(Fluoranthene + Pyrene)/ (C_2 + C_3 + C_4 Phenanthrenes)	Fraction of pyrogenic PAHs	Page *et al*. (2004)
(Acenaphthene + Acenaphthylene + Anthracene + Fluoranthene + Pyrene + Benzo[a]anthracene + Chrysene + Benzo[b]fluoranthene + Benzo[k]fluoranthene + Benzo[e]pyrene + Benzo[a]pyrene + Indeno[1,2,3-cd]pyrene + Dibenzo[a,h]anthracene + Benzo[g,h,i]perylene) ÷ (total PAH)	Pyrogenic PAH fraction	Boehm *et al*. (2004)
∑4-6 ringed PAH/Total PAH	Pyrogenic PAH fraction	Kennicutt (1998)
∑MP/P	Differentiation of fossil fuel sources (oil vs. coal); Petrogenic vs. pyrogenic PAHs	Gschwend and Hites (1981); Garrigues *et al*. (1995)
1,7-DMP/2,6-DMP	Differentiate PAHs from burning of biomass vs. fossil fuel combustion	Benner *et al*. (1995)
Double Ratio Plots (C_2Dibenzothiphene/C_2 Phenanthrene) vs. (C_3Dibenzothiphene/C_3Phenanthrene)	Petrogenic source differentiations	Boehm *et al*. (1983; 1997); Page *et al*. (1995b); Brown and Boehm (1993)
Double Ratio Plots (C_3Dibenzothiphene/C_3 Phenanthrene) vs. (C_3Dibenzothiphene/C_3Chrysene)	Weathered oil differentiation	Douglas *et al*. (1996); Sauer and Boehm (1995)
P/A	Differentiation of fossil fuel sources (oil vs. coal): Petrogenic: P/A >10 Pyrogenic: P/A <10	Gschwend and Hites (1981); Budzinski *et al*. (1997)
4,5DMP/∑MP	Oil vs. coal	Gschwend and Hites (1981); Garrigues *et al*. (1995)
FL/PY	Pyrogenic source differentiation Petrogenic: FL/PY < 1 Pyrogenic: FL/PY >1	Gschwend and Hites (1981); Emsbo-Mattingly and Boehm (2003)
Double ratio plot: P/A (y-axis) vs. FL/PY (x-axis)	Pyrogenic PAH source differentiation	Budzinski *et al*. (1997)
BaP/BeP; BbF/BkF; BaA/C	Pyrogenic PAH source types (wood, auto emissions, coal)	Dickhut *et al*. (2000); Costa and Sauer (2005)

FFPI = fossil fuel pollution index; P = phenanthrene; DBT = dibenzothiophene; C = chrysene;
MP = methylphenanthrene, DMP = dimethylphenanthrene; A = anthracene; FL = fluoranthene; PY = pyrene;
BaP and BeP = benzo[a] and benzo[e]-pyrene; BbF and BkF = benzo[b] and benzo[k]fluoranthene;
BaA = benzo[a]anthracene; C1, C2, C3, C4 = alkyl homologues, 1 through 4 carbons.

Table 6. Ratios of Phenanthrene to Anthracene (P/A) and Fluoranthene to Pyrene (FL/PY) from Different Sources of PAHs [adapted from Neff *et al.* (2005) for which the references are available]

Source	P/A	FL/PY	Reference
Primarily pyrogenic sources:			
Coke oven emissions	1.27 – 3.57	0.76 – 1.31	Maher and Aislabe (1992)
Iron/steel plant (soot)	0.24	0.62	Yang *et al*. (2002)
Iron/steel plant (flue gas)	0.06	1.43	Yang *et al*. (2002)
Wood-burning emissions	6.41	1.26	Page *et al*. (1999)
Auto exhaust soot (gasoline)	1.79	0.90	O'Malley *et al*. (1996)
Diesel engine soot	0.06	1.26	Bence *et al*. (1996)
Diesel exhaust particles (n = 22)	1.3 – 78	0.25 – 1.38	Sjøgren *et al*. (1996)
Highway dust	4.7	1.4	Christensen *et al*. (1999)
Urban runoff	0.56 – 1.47	0.23 – 1.07	Stout *et al*. (2001a)
Creosote	0.11 – 4.01	1.52 – 1.70	Neff (2002)
Coal tar	3.11	1.29	Neff (2002)
Coke	0.24	1.49	S.A. Stout (unpublished data)
Creosote-contaminated sediment (Eagle Harbor, WA)	0.34	1.59	Stout *et al*. (2001a)
Urban sediment (Eagle Harbor, WA)	0.22	0.79	Stout *et al*. (2001a)
Primarily petrogenic sources:			
60 crude oils (mean)	52.0	0.25	Kerr *et al*. (1999)
Australian crude oil	>370[a]	0.78	Neff *et al*. (2000)
Italian crude oil	>232[a]	0.08	Neff *et al*. (1998)
Alaska crude oil	>262[a]	0.2	Bence *et al*. (1996)
Diesel fuel (No. 2 fuel oil)	>800[a]	0.38	Bence *et al*. (1996)
No. 4 fuel oil	11.8	0.16	S.A. Stout (unpublished data)
Bunker C residual fuel oil	14.8	0.14	S.A. Stout (unpublished data)
Road paving asphalt	20	<0.11[a]	Kriech *et al*. (2002)
West Virginia coal (2 samples)	11.2, 27.9	0.95, 1.03	Neff and Sauer (1993)

[a] Anthracene or fluoranthene concentration was below the detection limit.
n = number of samples

Mahler *et al.* (2005) used the following PAH source ratios to distinguish coal tar as a PAH source: fluoranthene:pyrene, indeno [1,2,3-cd] pyrene:benzo[ghi]perylene, and benzo[a]pyrene:benzo[e]pyrene. Figure 6 illustrates how these PAH source ratios were used to determine that ratios in suspended sediment collected from four urban streams after storms most closely matched those ratios in particles washed from parking lots with coal tar emulsion sealcoat than ratios from particles washed from asphalt-sealed lots and from unsealed lots (Mahler *et al*. 2005). They also found this set of ratios to be better at distinguishing between the different parking lot samples and stream samples than ratios used for assessing combustion and noncombustion sources.

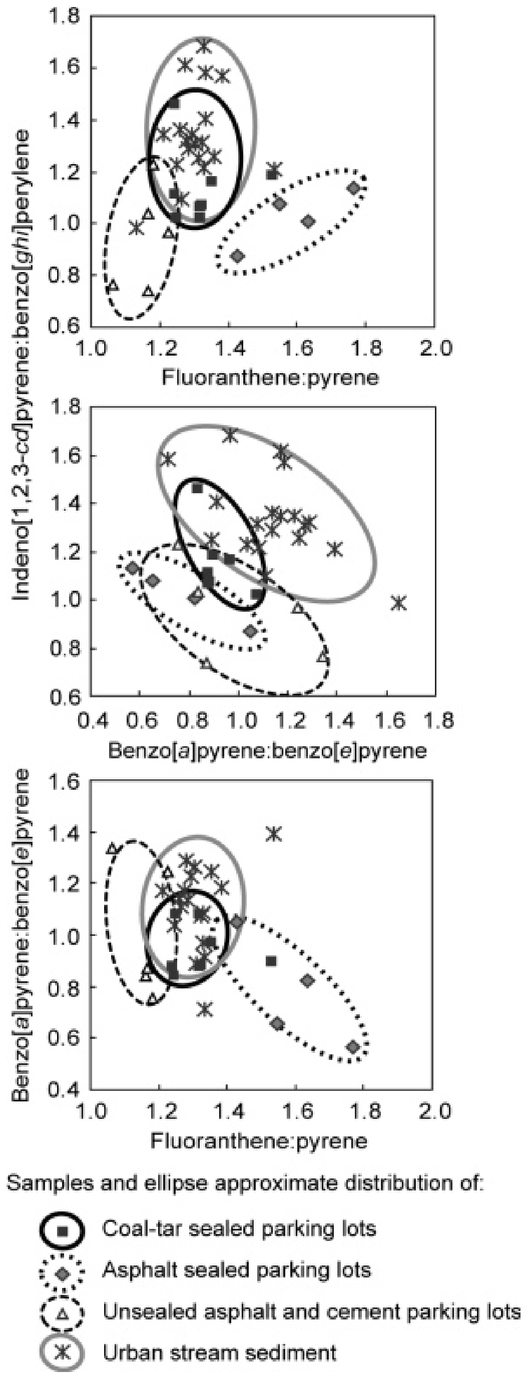


Figure 6. Comparison of indicator ratios of PAHs in particles washed from parking lots with coal tar emulsion sealcoat, asphalt emulsion sealcoat, and unsealed asphalt pavement and concrete pavement, and in suspended sediment collected from four urban streams after storms (Mahler *et al*. 2005).

Scientific Evidence Supporting Coal Tar Sealcoats as an Important Environmental Source of PAHs to Urban Sediments in Part of the U.S.

Types and uses of sealcoat products

Sealcoats are applied to the surface of asphalt walkways, playgrounds, driveways, and parking lots in order to protect the asphalt pavement and to provide a deep black appearance for cosmetic purposes (Figure 7). As a clarification, the sealcoating mentioned in this report differs from that used on residential streets that have a cover aggregate (e.g., gravel) added on top of the asphalt sealcoat (Janisch and Gaillard 1998). Sealcoating is marketed as reducing weather damage by preventing water from seeping into the porous asphalt structure. It also is purported to help prevent damage from UV radiation which can dry out the asphalt surface. In addition, sealcoating appears to protect asphalt pavement from the damaging effects of gas, oil, road chemicals, and winter salts (Yamada and Dimas 1999; Aaron Asphalt Contractors, Inc. web site accessed on 5/15/09 at: http://www.aaronasphalt.com/Sealcoating.htm). Confirmation of these attributes of sealcoating in the peer-reviewed literature was not apparent from a search of several internet search engines (i.e., Google, Google Scholar, Yahoo! Search, bing.com, and Exalead) on August 13, 2009 using a variety of search words such as “research study investigation advantages asphalt coal tar sealcoats.” A repeat of this web search query on February 2, 2010, did not yield any peer-reviewed articles in favor of either asphalt-based or coal tar-based sealcoats.

Figure 7. Sealcoat products are applied to parking lots and driveways in an effort to protect the asphalt pavement and for cosmetic purposes (image from: http://www.autocyclesealcoating.com/wp-content/uploads/2008/07/sealcoat3.jpg).

The University of New Hampshire Stormwater Center has conducted a comprehensive search for evidence that either asphalt-based or coal tar-based sealcoats increase the life span of the underlying asphalt. Although they have found some evidence of sealcoat protecting against corrosive spills, and possibly UV breakdown of the underlying binder, they have not found any research showing benefit to structural integrity (Personal Communication, Alison Watts, UNH Stormwater Center, September 4, 2009). The Pavement Coatings Technology Council, an industry group representing sealant producers and suppliers, is considering pursuing research that would determine whether sealcoats protect asphalt pavement and extend pavement life, according to an article in Pavement Maintenance and Reconstruction (http://www.forconstructionpros.com/publication/article.jsp?pubId=3&id=12080&pageNum=2).

There are three basic types of sealcoat products: asphalt emulsion-based, acrylic, and coal tar emulsion-based. Asphalt-based sealcoats are made from refined petroleum products while the coal tar-based sealcoats are made from refined coal tar, a by-product of coke production. Most coal tar sealcoats contain clay and water to enhance flexibility, and sand is added to provide additional traction. Sealcoat products differ in their PAH content. A study found that asphalt-based sealcoat ranged from 0.03 to 0.66% total $PAHs_{16}$ by weight, whereas coal tar-based sealcoat ranged from 3.4 to 20% total $PAHs_{16}$ by weight (Mahler *et al.* 2005). Acrylic asphalt sealcoats do not contain tar and are marketed as an environmentally friendly alternative to sealcoats containing coal tar (SealTECH Sealcoating Web site accessed on 5/15/09 at: http://www.sealtechsealcoating.com/ and Eco-Friendly Seal Coat LLC Web site accessed on 5/15/09 at: http://www.ecofriendlysealcoat.com/). The Metropolitan Council Environmental Services obtained the three types of sealcoat from two large home improvement stores in Apple Valley, MN during the spring of 2006 and analyzed them for 13 PAHs (Polta *et al*. 2006). The acrylic and asphalt-based sealcoats had similar low concentrations of total $PAHs_{13}$, whereas the coal tar-based sealcoat was 4 orders of magnitude greater in total $PAHs_{13}$ (Table 7; Polta *et al.* 2006).

Table 7. Characteristics of Three Types of Driveway Sealcoat Products (Polta *et al*. 2006)

Sealcoat Type	Specific Gravity*	% Solids	Total PAH_{13} mg/kg dry wt.**	Application Rate ft^2/gallon***
Acrylic	1.16	30.7	6.5	240
Asphalt	1.19	28.5	5.5	70
Coal Tar	1.04	16.8	42,840	90

* Determined using 25 mL graduated cylinder
** PAH concentrations not corrected for surrogate recovery
*** Label recommendations

Typically, reapplication is recommended every two to three years since the sealant is abraded off from wear and degraded in sunlight (Twin City Asphalt Web site accessed on 5/15/2009 at: http://www.twincityasphalt.com/sealcoating.shtml). This means a regular supply of sealants are being applied in urban areas. Coal tar-based sealcoats are used mostly in the central, southern, and eastern U.S., whereas asphalt-based sealcoats are used predominately in the western U.S. (Van Metre *et al.* 2008). Although coal tar-based sealant is more resistant to fuel spills, it is functionally similar to the asphalt-based sealants since both products are designed and marketed for the same use (Barnhart 2009).

Environmental fate and transport of PAHs associated with sealcoat products

Over time, vehicle traffic wears down the sealcoat, and oxidation by UV radiation can deteriorate the binder and expose the aggregate. Weathering by rain and snow, as well as abrasion from snow plowing and shoveling, can further break down the surface layer, resulting in flakes of sealcoat being abraded away. These flakes can be washed into storm sewer systems during rain events or by melting snow (Figure 8). Smaller flakes (dust) can become airborne and be transported via the atmosphere. Lower molecular weight PAHs may also directly volatilize to the air. Peaks in PAH concentrations have been found in sediments throughout metro regions of the country, including the Twin Cities, MN (Van Metre and Mahler 2005). Coal tar-based sealcoat may dominate PAH loading to urban water bodies in the U.S. (Mahler *et al*. 2005). For example, the New York Academy of Sciences concluded that coal tar sealcoat was a major contributor to loadings of PAHs to the New York/New Jersey Harbor (Valle *et al*. 2007). In addition, pavement dust and runoff from coal tar-based sealcoated driveways and parking lots are emerging as primary sources of PAHs to urban environments, especially in the midwestern, southern, and eastern United States (Van Metre *et al*. 2008; Van Metre and Mahler 2009). The City of Austin, TX used a novel photographic method to determine a relatively rapid wear rate for coal tar sealcoat from parking lots, and they speculated that windblown dust and mechanical transport of sealcoat particles could be quite large in addition to runoff (Scoggins *et al*. 2009).

PAHs associated with sealcoat products could also potentially contaminate soil and groundwater during stormwater runoff events and from stormwater ponds and other BMPs. The USGS evaluated the water quality of a surficial aquifer system in central Florida (i.e., Orlando and Longwood, FL) to one exfiltration pipe, two ponds (detention and retention), and two swales to detect any effects from infiltrating highway runoff (Schiffer

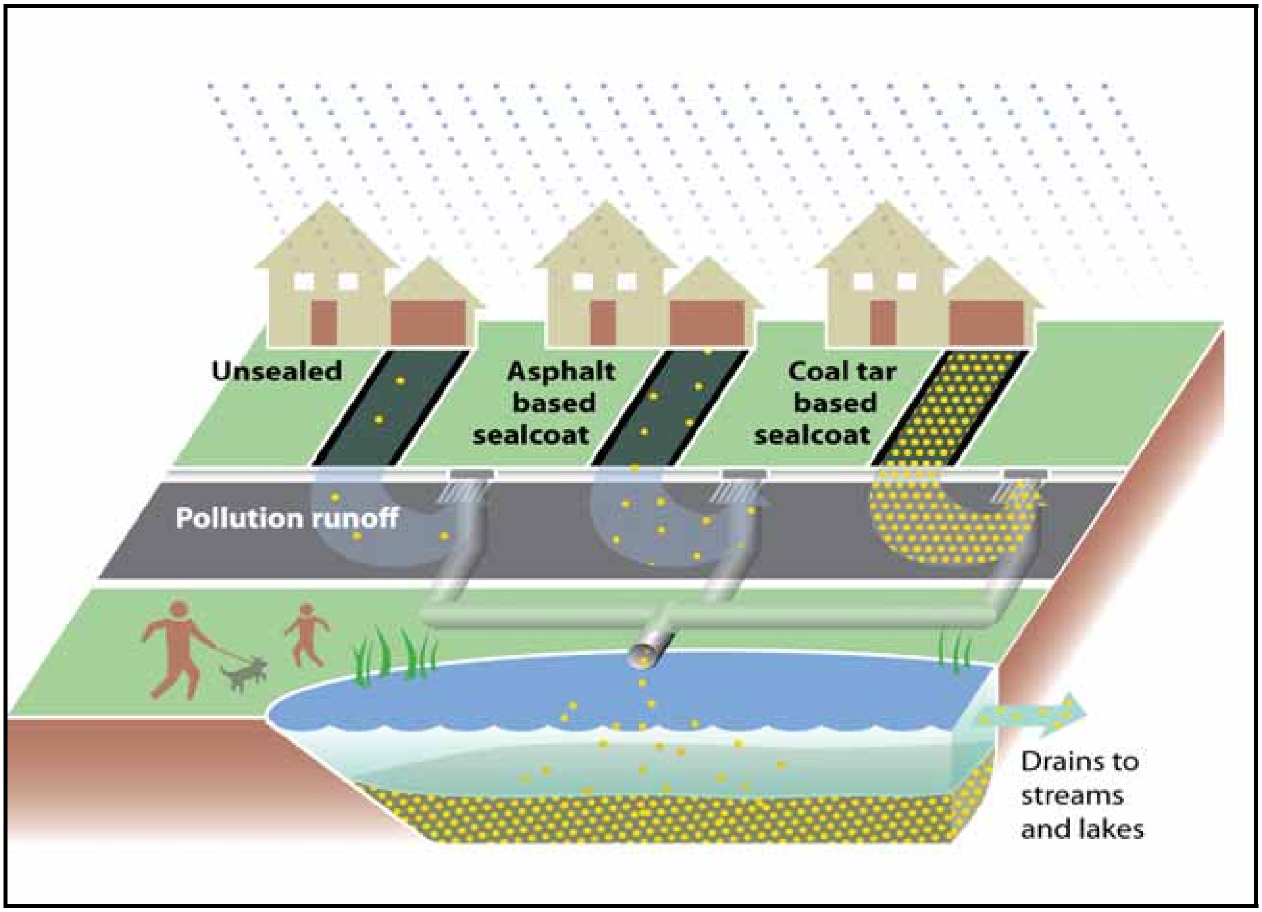


Figure 8. Diagram showing sources of PAHs (yellow dots) to a stormwater pond due to wet runoff of unsealed driveways, driveways sealed with asphalt-based sealcoat, and driveways sealed with coal tar-based sealcoat. During rain and snowmelt events, PAHs associated with particles runoff from the driveways into the storm sewer system with subsequent deposition to neighboring stormwater ponds.

1989). Elevated concentrations of PAHs were measured in the sediments of the retention pond, but a qualitative assessment of PAHs in groundwater from three nearby wells showed only one well had detectable concentrations of PAHs, which were low (Schiffer 1989). Since this was an older study, the potential contributions of PAHs from nearby coal tar sealed parking lots and driveways were not assessed. Simon and Sobieraj (2006) conducted a literature review to examine the potential for PAHs from sealcoats to be transported from parking lots to adjacent soil, sediment, or groundwater. They did not find many studies, but postulated that PAHs would be relatively immobile in subsurface soils due to their physical-chemical properties, and migration to groundwater would be limited to PAHs associated with the dissolved fraction and mobile colloidal particles (Simon and Sobieraj 2006). The University of Minnesota conducted a literature review of scientific and engineering journals to assess impacts of stormwater infiltration on groundwater (Weiss *et al.* 2008). Although the availability of studies was limited, Weiss *et al.* (2008) found that metals and hydrocarbons are usually removed in the upper 20 – 50 cm of soil and the rest of groundwater contamination was usually low. However, karst areas and other permeable subsurface areas provide a greater likelihood for groundwater contamination. A Swedish study (for which only the abstract was obtained) investigated the vertical leaching of organic contaminants, including PAHs, in road ditches, as well as in stormwater sediment, urban soil, and shallow groundwater (Strömvall *et al.* 2007). Total PAH concentrations in soil were less than 1 mg/kg dry wt., and were detected down to 1.5 m in a road ditch, whereas total PAH concentrations in urban shallow groundwater were reported as high (although a concentration value was not provided in the abstract;

Strömvall *et al*. 2007). Additional studies are needed to gauge the transport and attenuation of PAHs in soil and groundwater from stormwater sources.

The USGS led some of the first studies quantifying the transport and fate of sealcoat products to urban waterways. These studies will be summarized in this section, in addition to studies from other researchers. Together, these studies provide a scientific weight-of-evidence that support restrictions or bans on the use of coal tar-based sealcoat products in Minnesota and elsewhere.

USGS studies

In response to suggestions by the City of Austin, TX that abraded parking lot sealcoat could be the source of elevated PAH concentrations in sediments from a local stream, the USGS conducted a parking lot runoff study within Austin, TX (Mahler *et al*. 2005). Parking lots were assigned to four groups: 1) cement, 2) unsealed asphalt, 3) asphalt-based sealcoat, and 4) coal tar-based sealcoat. Light rainfall events were simulated over a section of each parking lot, and the resultant particulate fraction in the stormwater runoff from each parking lot group was collected and analyzed for thirteen PAHs. Means and ranges of the summed PAHs ($\sum PAH_{13}$) for each pavement type are given in Table 8. The asphalt-based sealed parking lot produced mean PAH runoff 11 times higher than the unsealed (asphalt and cement) parking lots, and the coal tar-based sealed parking lots produced PAH runoff 65 times greater than the unsealed parking lots (Table 8). Diagnostic ratios of individual PAHs were used to show the sources of PAHs were similar for particles from the coal tar sealed lots compared to suspended sediment collected from four urban streams during a storm flow event. Mahler *et al*. (2005) estimated that if parking lots were left unsealed in their studied watershed, PAH loads would be reduced by 5 – 11%. On the basis of analyses of coal tar and asphalt-based sealcoat products by the City of Austin, TX (McClintock *et al*. 2005) in relation to Austin parking lot runoff and dust results (Mahler *et al*. 2005; Van Metre *et al*. 2008) and on the history of sealcoat application in Austin, Peter Van Metre (USGS) concluded that the asphalt lots sampled in Austin probably were contaminated with PAHs from historical use of coal tar-based sealcoats (Peter Van Metre, personal communication with Judy Crane by email, August 17, 2009). Sealcoated lots in some western cities support this conclusion with dust concentrations about 100 times less than supposedly asphalt sealed lots in Austin, TX (Van Metre *et al*. 2008).

Table 8. Concentrations of Particulate PAHs in Runoff Samples from Unsealed and Sealed Parking Lots (Mahler *et al*. 2005)

Pavement Type	Mean ΣPAH_{13} (mg/kg dry wt.)	Number of Samples	Range ΣPAH_{13} (mg/kg dry wt.)	Mean ΣPAH_{13} Relative to Unsealed Pavement
Unsealed (asphalt or cement)	54	4	7.2 - 75	-
Asphalt Sealcoat	620	3	250 - 830	11 times higher
Coal Tar Sealcoat	3500	6	520 - 9000	65 times higher

In a recent national study of nine U.S. cities, USGS investigators (Van Metre *et al*. 2008) looked at the role of dust from sealed and unsealed parking lots as a mechanism for the transport of PAHs from these urban areas. Total PAHs were determined by summing 12 parent PAHs. They found low median PAH concentrations in dust sweepings from asphalt sealcoated and unsealed parking lots at western U.S. sites (e.g., 2.1 and 0.8 mg/kg dry wt., respectively). In contrast, central and eastern U.S. sites showed median PAH concentrations of 2200 and 27 mg/kg dry wt., for sealcoated (dominated by coal tar sealcoats) and unsealed lots, respectively. The same pattern was noted in lake sediments contaminated with PAHs from adjacent areas. It is unlikely that other sources of PAHs would be creating this disparity because the cities sampled had a similar amount of urbanization. Therefore, it is expected that they would have similar source levels. This study concluded that "Concentrations of benzo[a]pyrene in dust from coal tar-based sealcoated pavement and adjacent soils greatly exceed generic soil screening levels, suggesting that research on human health risk is warranted" (Van Metre *et al*. 2008).

Another recent study by the USGS examined sources of PAHs in post-1990 deposited sediments in 40 urban lakes from across the U.S. (Van Metre and Mahler 2009). A contaminant mass balance receptor model was used to examine correlations between the sediment profiles and five general source categories (i.e., coal combustion, oil combustion, vehicle emissions, wood combustion, and coal tar-based sealcoat). The strongest correlation was found for sealcoat dust (r = 0.95). Vehicle emissions and coal combustion followed sealcoat in importance as a source of PAHs to the sediments.

Collaborative work between the USGS, the Wisconsin Department of Natural Resources (WDNR), and the MPCA provided additional data on concentrations of PAHs from different source areas and land uses within an urban environment (Selbig 2009). This study was conducted in the vicinity of Madison, WI which as part of Dane County, was the second municipality in the U.S. to ban coal tar sealcoat products in 2007. Stormwater runoff was monitored from the following land uses:

- Unsealed parking lots;
- Sealed parking lots (i.e., asphalt and coal tar-based);
- Three road-types (i.e., residential, collector, and arterial) with increasing vehicular traffic;
- A strip mall (mixed use, including runoff from a parking lot, roofs, sidewalks, and grassy areas), and a
- Commercial rooftop composed of rubber.

During the 2007 and 2008 monitoring period, 9 to 27 samples were collected at each site (Selbig 2009). The samples were analyzed for 16 parent and 2 alkylated PAH compounds. Three HPAHs (i.e., chrysene, fluoranthene, and pyrene) were the dominant PAH compounds in all samples; this result was consistent with previous studies of PAHs in urban stormwater (Steuer *et al*. 1996; Stein *et al*. 2006). The highest mean total PAH_{18} concentrations were measured in runoff from the sealed parking lots (52.3 µg/L) which were over six times greater than those measured in runoff from the untreated parking lots and twice as great as measured in stormwater from the arterial roads (Figure 9). For the other land uses, the mean total PAH_{18} concentrations were all less than 6.5 µg/L (Figure 9). Other summary statistics are provided in Table 9. Descriptive statistics for data sets with censored values (i.e., values less than the laboratory's limit of detection) were calculated by use of the nonparametric Kaplan-Meier method (Helsel 2005). Total PAHs were summed from the individual, uncensored PAH compounds detected in each sample. Due to the range of values observed, the median values may be more representative of environmental samples. The highest median total PAH concentrations were measured in runoff from coal tar treated parking lot (52.3 µg/L) followed by the strip mall, arterial street and unsealed parking lot (e.g., ~5 - 6 µg/L) and then collector and residential streets and the commercial rooftop (e.g., 0.05 to 2.4 µg/L). In addition, runoff from coal tar sealed parking lots in this study and an analogous one

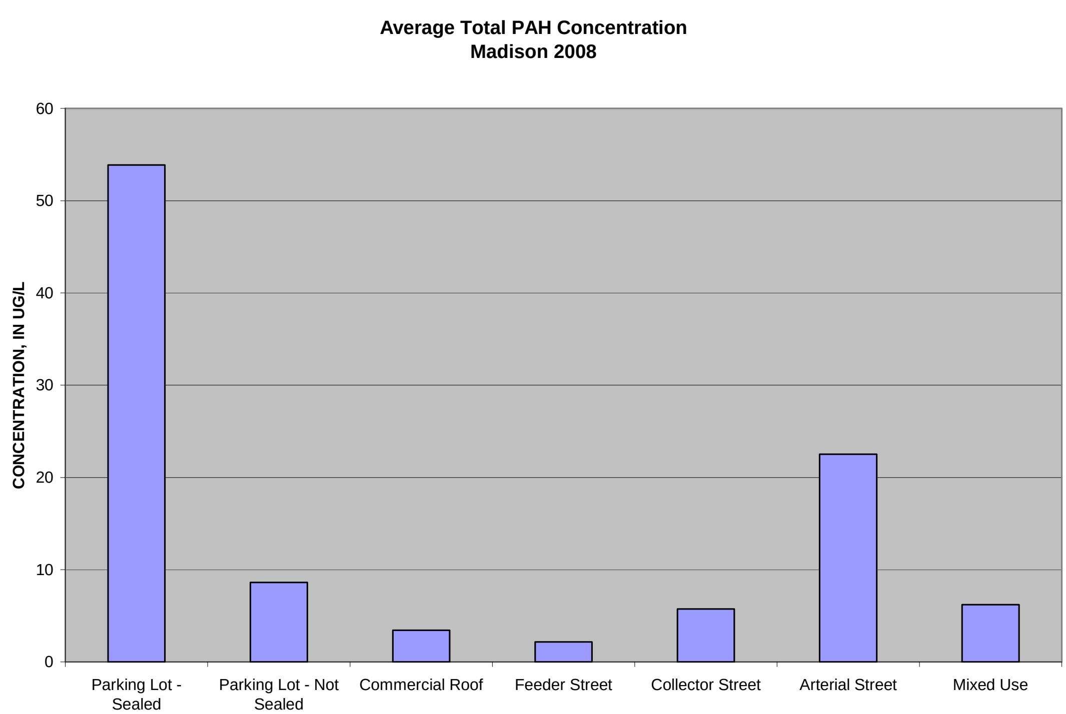


Figure 9. Concentrations of mean total PAH_{18} in stormwater runoff from varied land uses (Selbig 2009).

Table 9. Summary Statistics of Total $PAHs_{18}$ in Urban Stormwater Measured near Madison, WI (Selbig 2009)

Parameter	Parking Lots		Roofs	Streets			Mixed
	Sealant	No Sealant	Commercial	Residential Feeder	Collector	Arterial	Strip Mall
Number of Samples	15	27	9	15	15	11	19
Total $PAHs_{18}$ (µg/L)							
Minimum	14.6	4.98	0.12	ND	ND	2.05	0.14
Maximum	95.6	71.2	13.6	11.1	42.9	99.0	14.8
Median	52.3	4.76	2.40	0.05	1.83	5.72	5.72
Mean	53.9	8.62	3.44	2.16	5.74	22.5	6.21
Standard Deviation	24.0	14.0	3.92	3.86	12.5	32.3	4.75
Coefficient of Variation	0.45	1.62	1.14	1.79	2.17	1.43	0.76

ND = Not Detected

in Marquette, MI (Steuer *et al*. 1997) had similar geometric mean concentrations of total PAHs despite the distance between locations and length of time between studies (Selbig 2009); the study results were also consistent with the results of Mahler *et al*. (2005) from coal tar sealed parking lots in Austin, TX.

A new study by the USGS and its collaborators found a link between PAHs in settled house dust and the proximity of coal tar-based sealcoated parking lots in Austin, TX (Mahler *et al*. 2010). These researchers measured the 16 priority pollutant PAHs in settled house dust from 23 apartments, as well as in dust from the parking lots for each apartment. Additional data were collected on a variety of lifestyle variables and site characteristics that could potentially affect PAH concentrations. Only two variables were significant in relation to total $PAHs_{16}$ in settled house dust: the presence or absence of coal tar-based sealcoat on the parking lot for the apartment (which explained 48% of variance) and urban land use within a 250 m radius of the residence (which explained 30% of variance). Total $PAHs_{16}$ in settled house dust from apartments with coal tar sealed parking lots (median = 129 µg/g) was 25 times higher than that in dust from apartments with parking lots with other pavement surface types (median = 5.1 µg/g). This ratio was less than the median concentration of total $PAHs_{16}$ in dust from adjacent coal tar sealed parking lots (median = 4760 µg/g, n = 11) that was 530 times higher than that from parking lots with other surface types (median = 9.0 µg/g, n = 12). Other variables such as presence of carpeting, frequency of vacuuming, and indoor burning were not significant in explaining total $PAHs_{16}$ in settled house dust (Mahler *et al*. 2010).

Several academic researchers collaborated with USGS researchers to study how coal tar sealcoat and other carbonaceous materials influence the loading of PAHs in an urban watershed in Fort Worth, TX (Yang *et al.* 2010). Samples of soils, parking lot and street dust, as well as streambed and lake sediment were collected from the highly urbanized Lake Como watershed. Total PAHs, based on 13 LMW and HMW PAHs, were highest in coal tar sealed parking lot dust (Figure 10). The mass distribution of carbonaceous materials from the study sites is provided in Figure 11. These researchers attributed the source of coal tar pitch in streambed sediment and surficial lake sediment to parking lot runoff. Correlations between log (total PAH_{13}) and organic carbon of selected carbonaceous materials show that coal tar, asphalt, and soot particles are likely sources or carriers for PAHs in this watershed, and that PAH concentrations in the stream and lake are more affected by carbonaceous materials from commercial land use areas than from residential areas. Additional statistical comparisons between PAH profiles in sources and receptors supported the major conclusion of this study that coal tar-based sealcoat (through coal tar pitch) is a primary source and transport vector of PAHs in this particular watershed.

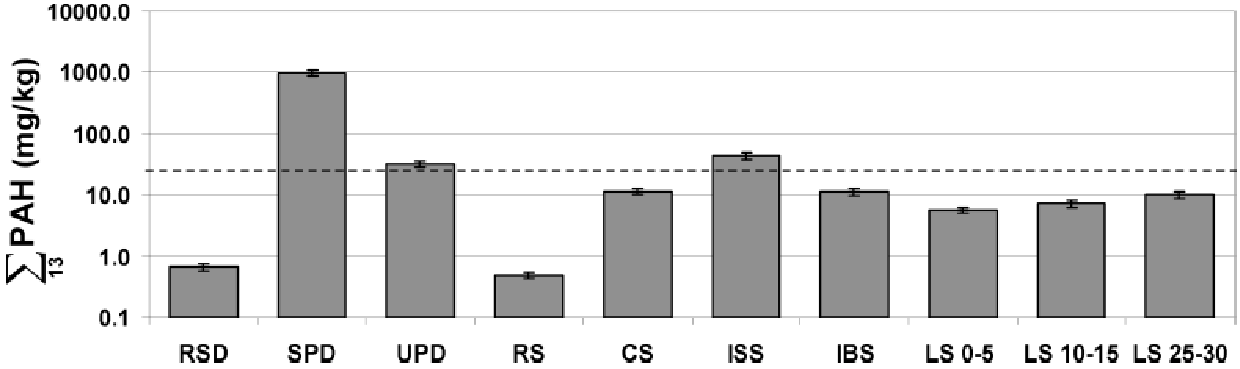
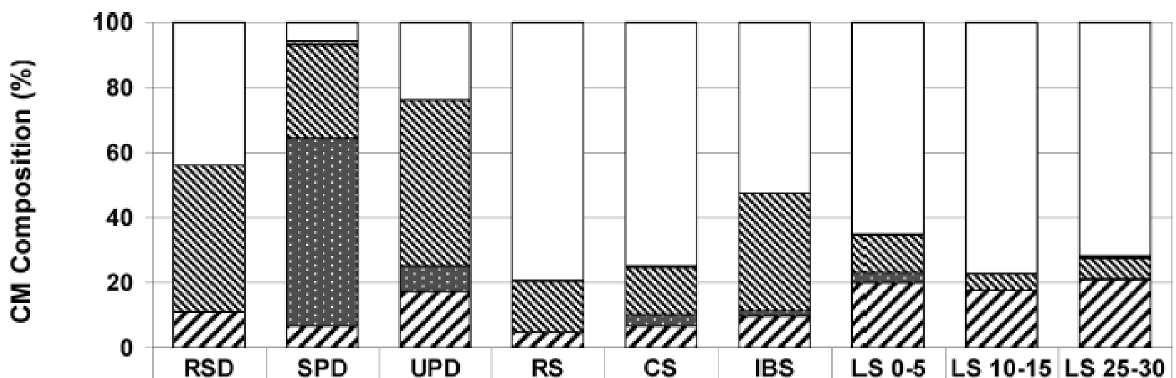


Figure 10. Total PAH concentrations in samples of residential street dust (RSD), sealed parking lot dust (SPD), unsealed parking lot dust (UPD), residential area soil (RS), commercial area soil (CS), influent suspended sediment (ISS), influent streambed sediment (IBS), lake sediment from 0-5 cm depth (LS 0-5), lake sediment from 10-15 cm depth (LS 15-20), and lake sediment from 25-30 cm depth (LS 25-30) [Σ13PAH as used here is the sum of the detected and estimated concentrations of the 13 PAHs used in the consensus-based sediment quality guidelines of MacDonald *et al*. (2000): acenaphthene, acenaphthylene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, benz[*a*]anthracene, dibenz[*a,h*]anthracene, benzo[*a*]pyrene, chrysene, fluoranthene, and pyrene; the dashed line indicates the PEC value of 22.8 mg/kg for total $PAHs_{13}$ (MacDonald *et al*. 2000)].



	RSD	SPD	UPD	RS	CS	IBS	LS 0-5	LS 10-15	LS 25-30
□ Recent OM	43.7	5.8	24.0	79.0	75.0	52.4	65.1	77.3	71.7
Hard Coal	0	0.8	0	0.3	0.3	0	0.3	0	0.5
□ Char	0	0	0	0	0	0	0	0.1	0
Coke	0	0.3	0	0.3	0	0.3	0.3	0	0.3
Asphalt	45.1	29.0	50.9	15.8	14.5	36.1	11.1	5.1	6.2
Coal-Tar Pitch	0	57.5	7.8	0	3.6	1.4	3.2	0	0.4
Soot	11.2	6.7	17.3	4.5	6.6	9.8	20.1	17.5	20.9

Figure 11. Mass percentages of carbonaceous materials (CMs) in samples [one standard deviation of every maceral (i.e., component of coal or oil shale) in every sample is within 3%; Yang *et al*. 2010].

University of New Hampshire study

The University of New Hampshire's Stormwater Center (UNHSC) conducted a study where one-quarter acre of a parking lot located near the UNHSC was covered with coal tar-based sealcoat and the other nine acres of parking lot were left unsealed (Figure 12; Watts *et al.* 2008). PAH concentrations were measured in the water and sediments adjacent to the sealcoated and unsealed parking lot sections. Up to 5,890 µg/L PAHs were measured in the initial runoff of the sealed lots compared to less than 10 µg/L PAHs from the unsealed lot (Watts 2009). The concentrations decreased after several rainstorms to less than 100 µg/L PAHs at the sealcoated site. The concentrations of PAHs in the sediments immediately downstream of the coal tar sealed lot increased by nearly two orders of magnitude within the first year (Figure 13; Watts 2009).

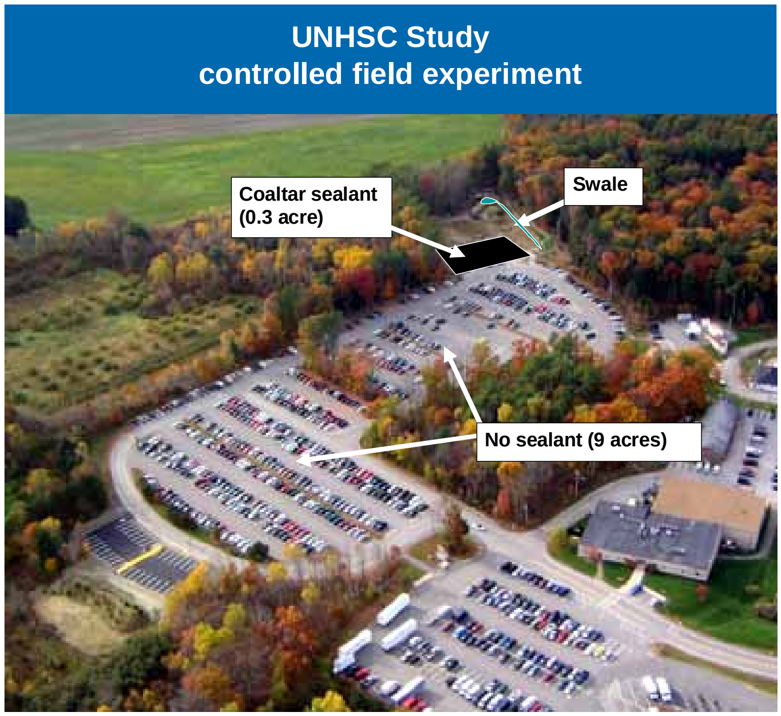


Figure 12. Study sites for an investigation of PAH runoff from sealcoated pavements (Watts *et al*. 2008).

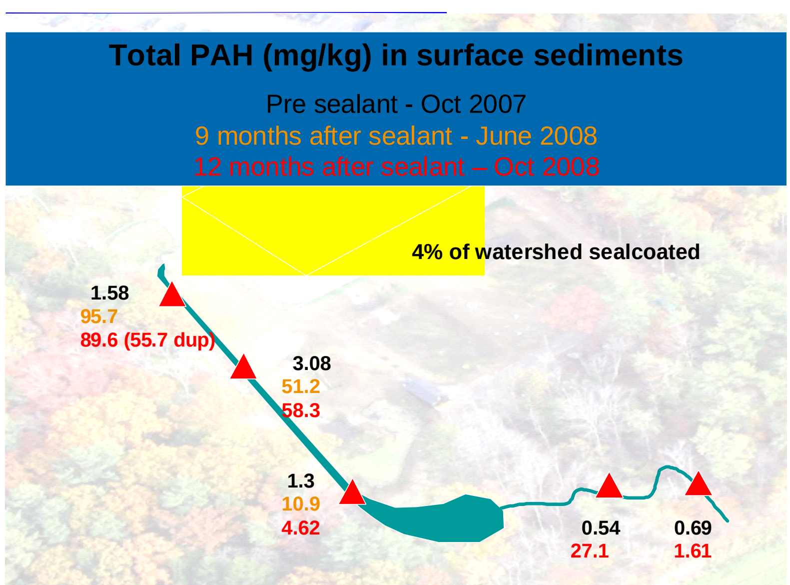


Figure 13. Increase in sediment-associated PAH concentrations resulting from a parking lot treated with coal tar sealcoat (Watts 2009).

City of Austin, TX study

Researchers from the Environmental Resource Management Division of the City of Austin, TX used a novel photographic method to estimate the wear of coal tar sealcoat from ten coal tar sealed parking lots in Austin, TX (Scoggins *et al*. 2009). The age of the sealcoat ranged from 0 to 5 years. The parking lots were divided into parking-space area (park) and drive-isle area (drive) of which a minimum of three and a maximum of 20 photos were taken from randomly selected spots in each area. The photographs were analyzed digitally to quantify black sealed areas versus lighter colored unsealed areas at the pixel level. The driving areas of the parking lots lost more coal tar sealcoat (i.e., 4.7% per year) than the parking areas of the lots (i.e., 1.4% per year) with an overall annual loss of 2.4% of coal tar sealcoat. The annual load from the parking lots was calculated as 0.51 g of PAHs per m^2 of coal tar sealed parking lot.

U.S. EPA studies

The U.S. EPA's Office of Research and Development (ORD) is currently conducting research on the impacts of PAHs derived from storm-induced parking lot runoff and related work on PAHs. U.S. EPA Acting Assistant Administrator Lek Kadeli provided the following update on the EPA's activities in a letter dated July 29, 2009 to Congressman Lloyd Doggett (D-Texas) of the U.S. House of Representatives based on his earlier request for information. Representative Doggett included language in the 2009 House Appropriations bill requesting the U.S. EPA to study human health effects and ecosystem impacts from exposure to PAHs through parking lot sealcoatings.

> "Contaminants in stormwater runoff from parking lots may be derived from materials leached from various sealants, including coal tar products, and are likely to include other contributing sources (e.g., automobiles, air deposition). Because of the complexity of the mixtures that can occur in parking lot stormwater runoff, initial laboratory studies are being designed to focus on research to assess environmental concentrations and evaluate the acute impacts of leached PAHs and co-occurring compounds on the potential toxicity to receiving waters and aquatic life. Specific to coal tar-based sealants, the ORD facility in Edison, NJ has completed the planning for experiments involving both bench-scale and full-scale applications of parking lot sealants, including the fate and bioavailability of PAHs. Based on the monitoring findings, appropriate toxicity studies will be conducted. Laboratory studies to address chemical releases and potential toxicity from volatilized and leached compounds from coal tar and latex sealant materials will begin in late 2009. We expect preliminary results in approximately 18 months from the commencement of the studies. ORD-Edison has a long history of providing leadership in stormwater research, specifically identifying pollutant loading in stormwater runoff. Related to this work, two full-scale facilities are also being developed at the Edison facility. One is a new parking lot that is being constructed to test the use of porous pavements and the other is an existing asphalt parking lot that can be used for sealant and run-off studies.
>
> In addition, EPA has developed a human health assessment for PAHs, as recommended in the FY2008 House Full Committee Appropriations Report. The assessment includes an approach for assessing the carcinogenicity of PAH mixtures and is being developed by EPA's Integrated Risk Information System (IRIS) Program. The document has undergone internal peer consultation and Agency review and will undergo independent peer review by EPA's Science Advisory Board. It provides important information, which can be combined with exposure data for evaluating the potential human health risks associated with exposure to PAHs, including exposure through volatilization or storm water runoff from surfaces coated with coal-tar sealants. The assessment is expected to be available for public comment in late 2009."

Environmental Distribution of PAHs in Urban Aquatic Systems

The distribution of PAHs in urban aquatic systems may be influenced by watershed features such as the size of the watershed and lake area, as well as by land use features such as the percent of development, impervious surfaces, forests, cultivated land, pasture and open areas, and water and wetlands. The sedimentation rate and sediment dilution (i.e., from mixing with cleaner sediments) also affect the concentration of PAHs in sediments (Van Metre *et al*. 2000). Historical sources of PAH contamination, whether in upland hazardous waste sites, landfills, coal gasification plant sites, and/or creosote wood treatment facilities in the watershed, or in-place contaminated sediments resulting from historical discharges into waterways can contribute to contamination of urban waterways. Combined with current nonpoint and point sources of PAHs, urban aquatic systems are particularly susceptible to a mixture of PAH compounds from different sources.

This section will provide case study examples of the distribution of PAHs in urban areas, including a harbor/estuary system, urban lakes across theU.S., and stormwater ponds in Minnesota and South Carolina. As such, this section highlights the large variation in PAH concentrations observed in these aquatic environments, as well as the prevalence of pyrogenic PAHs in urban sediments. The MPCA is also currently conducting a study examining the distribution of parent and alkylated PAHs, along with several other chemicals of potential concern, in the surface sediments of a random selection of 50 lakes located throughout Minnesota. Once these data are evaluated, estimates of anthropogenic background concentrations of PAHs will be developed to provide an important benchmark for comparing PAH concentrations in other aquatic systems throughout the state. For further information about this statewide study, contact either Judy Crane at judy.crane@state.mn.us or Steve Hennes at steven.hennes@state.mn.us.

Urban Harbors and Estuaries

The St. Louis River Area of Concern (AOC) encompasses the twin ports of Duluth, MN and Superior, WI at the western terminus of Lake Superior (Figure 14). Historical development has contributed a mixture of contaminants to this waterway, including PAHs, mercury, and PCBs. Several sediment quality and fish tissue studies have been conducted in this AOC to delineate the extent and magnitude of contaminants of potential concern and to assess the potential for ecological and human health effects. The MPCA and its collaborators have assembled these data into a GIS-based sediment quality database (Crane 2006a; Crane and Myre 2006).

Polycyclic aromatic hydrocarbons are a widespread contaminant of concern in this AOC, primarily as a result of past industrial uses (coking, coal gasification plants, steel production) and current nonpoint sources of PAHs from the watershed. Two Superfund sites and several other contaminated hot spot sites (e.g., boat slips) have an elevated mixture of contaminants in the sediments which are best represented by the mean PEC-Qs (Figure 14; Crane 2006b). PAHs frequently comprise the largest component of the mean PEC-Qs. The mean PEC-Qs provide a screening-level indication of the risks benthic organisms may be exposed to from a mixture of contaminants in the surface sediments of the St. Louis River AOC (Crane 2006b). The MPCA uses a mean PEC-Q of 0.1 as the Level I SQT and a mean PEC-Q of 0.6 as the Level II SQT (Crane and Hennes 2007).

A technical report on sediment quality conditions in the lower St. Louis River summarized most of the sediment quality data collected since 1990 in the AOC (Crane 2006b). The summary statistics for 13 PAHs, total PAH_{13}, LPAHs, and HPAHs in surface (0 - 30 cm) and subsurface (>30 cm) sediment samples, as well as a summary of phenanthrene/anthracene (P/A) and fluoranthene/pyrene (FL/PY) ratios for selected depth intervals are provided in Appendix D. The P/A and FL/PY ratios are supportive of pyrogenic (combustion) sources of PAHs to this AOC (Crane 2006b). The median concentrations of PAHs in the surface sediments were statistically less ($p<0.05$) than in the subsurface sediments for: acenaphthene, acenaphthylene, anthracene, fluorine, naphthalene, phenanthrene, total $PAHs_{13}$, and LPAHs (Table 10; Crane 2006b). Each of these individual PAH compounds are LPAHs, which are more volatile and water soluble than HPAHs.

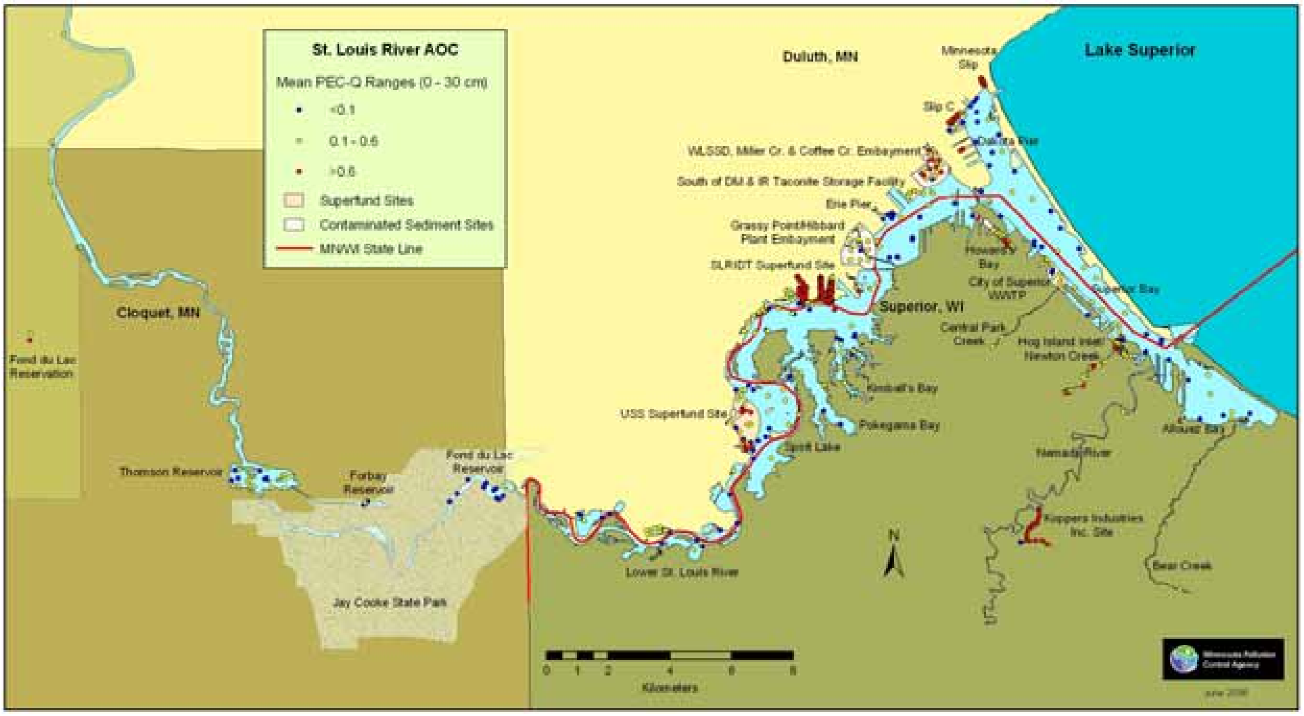


Figure 14. Distribution of mean PEC-Q values in the surface sediments (i.e., upper 30 cm) of the St. Louis River AOC (Crane 2006b).

Table 10. Determination of Statistical Significance Between Median Chemical Values in Surface and Subsurface Sediments from the St. Louis River AOC (Crane 2006b)

PAHs (µg/kg dry wt.)	Surface: N	Subsurface: N	Surface: Median*	Subsurface: Median*	Statistical Significance**
2-Methylnaphthalene	361	342	***230***	***320***	No (p = 0.171)
Acenaphthene	616	380	*59.7*	***240***	Yes (p = <0.001)
Acenaphthylene	632	388	*46.9*	*117*	Yes (p = <0.001)
Anthracene	668	399	*230*	*497*	Yes (p = 0.002)
Fluorene	662	397	*136*	*330*	Yes (p = <0.001)
Naphthalene	566	390	*240*	***661***	Yes (p = <0.001)
Phenanthrene	674	402	*619*	*1170*	Yes (p = 0.013)
Benzo[a]anthracene	671	400	*616*	*800*	No (p = 0.323)
Benzo[a]pyrene	677	404	*500*	*540*	No (p = 0.540)
Chrysene	675	402	*649*	*775*	No (p = 0.808)
Dibenzo[a,h]anthracene	628	390	*75*	*71*	No (p = 0.094)
Fluoranthene	677	404	*1100*	*1485*	No (p = 0.288)
Pyrene	677	404	*1000*	*1235*	No (p = 0.381)
Total $PAHs_{13}$ (exclude high ND)	677	404	*5930*	*11475*	Yes (p = 0.007)
HPAHs (exclude high ND)	677	404	4249	5155	No (p = 0.425)
LPAHs (exclude high ND)	674	402	1431	4426	Yes (p = <0.001)

N = number of samples; ND = nondetect

* Values in italics and yellow shading exceed the corresponding Level I SQT; values in bold italics and orange shading exceed the corresponding Level II SQT.

** All chemical pairs failed the test for normality (p<0.050). Statistical significance (green shading was determined using the nonparametric Mann-Whitney Rank Sum test.

Urban Lakes

Sediment cores can be used as an integrative record of contamination over time, especially when combined with radioisotope dating. Several studies conducted in the 1970s and 1980s showed regional decreases in PAH concentrations in sediment cores collected from remote and urban areas compared to earlier periods of time (several references cited in Van Metre *et al*. 2000). During that time period, the loading of PAHs from multiple sources to the environment was reduced through more stringent regulations (e.g., Clean Air Act, Clean Water Act), through the cleanup of contaminated upland sites, through the centralization and increased efficiency of power plant operations, and from the switch away from coal to heating oil and natural gas for home heating (several references as cited in Van Metre *et al*. 2000; Van Metre and Mahler 2005). However, a more recent study (Van Metre *et al*. 2000) showed the decreasing trend of PAHs has been reversed during the past 20 - 40 years. In this study, ten lakes and reservoirs in six urban areas across the U.S. were sampled, including two Twin Cities metropolitan area lakes: Lake Harriet (Minneapolis, MN) and Palmer Lake (Brooklyn Center, MN). Total PAHs were determined as the sum of 19 parent PAHs, ten specific alkyl-PAHs, and the homologous series of alkyl-PAHs, excluding perylene (a natural source PAH).

Lake Harriet, last of the Minneapolis Chain of Lakes, is part of the oldest urban regional park in the state and was heavily urbanized prior to 1960 (Figure 15). Sediment samples from this lake showed a peak of PAHs during the 1950s with a subsequent decrease in PAHs until the 1980s when PAHs increased again (Van Metre *et al*. 2000). The decrease was attributed to a shift of home heating from coal-based units to natural gas and oil, as well as improvements in the efficiency of power plants. However, increases from other PAH sources (possibly traffic-related) in the 1980s caused an upswing in the distribution of PAHs (Van Metre *et al*. 2000). It should be noted that the Minneapolis Chain of Lakes receives 5.5 million visitors per year, and it is a popular area for nonmotorized boating, running, walking, and bicycling. Hence vehicular traffic can be heavy in the immediate watershed. Lake Harriet, along with the other Minneapolis Chain of Lakes, was included in one of the largest urban lake restoration projects in the U.S. in which improvements were initiated in 1995 (http://www.epa.gov/nps/success/state/mn_chain.htm). Through a widespread public education campaign, sediment control measures, and implementation of other BMPs, significant in-stream reductions in sediment and phosphorus were achieved through this chain of lakes (Figure 15).

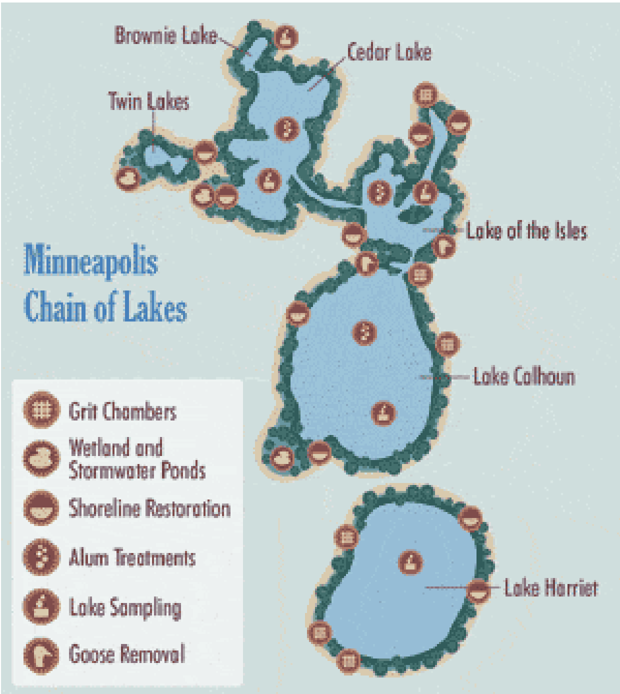


Figure 15. Restoration efforts in the Minneapolis Chain of Lakes, including Lake Harriet (source: U.S. EPA Web site at http://www.epa.gov/nps/success/state/mn_chain.htm).

Unlike Lake Harriet's stable urban watershed, Palmer Lake has experienced a much more recent increase in watershed urbanization (Figure 16). In the 1970s, urbanization was at 29.6% and had grown to 65.6% in the 1990s, a 122% increase (USGS 1990 and Hitt 1994 as cited in Van Metre *et al*. 2000). Sediment samples from Palmer Lake showed rapid increases in total PAHs, especially after 1990. Both Harriet and Palmer Lakes displayed a similar range of total PAHs in the sediment cores collected from these lakes: 430 – 48,300 µg/kg dry wt. for Lake Harriet and 518 – 45,700 µg/kg dry wt. for Palmer Lake (Van Metre *et al*. 2000). Concentrations of total PAHs increased in all ten reservoirs and lakes during the past 20 – 40 years, and this increase was attributed to combustion (i.e., pyrogenic) sources. The increase in PAH concentrations compared well with an increasing trend in vehicle miles traveled on freeways and major arterial streets for these urban areas. However, the increased contamination of lake and reservoir sediments by PAHs in these urban areas could not be absolutely attributed to increases in automobile usage.

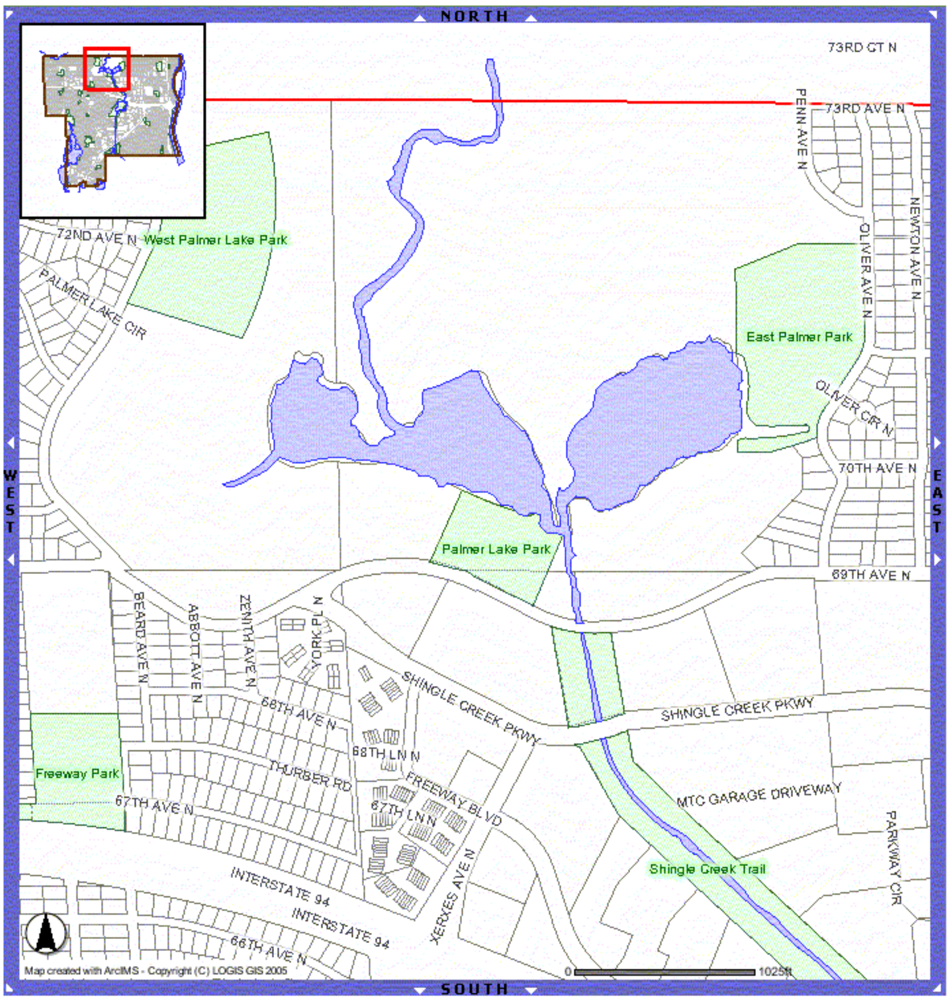


Figure 16. Map of Palmer Lake in Brooklyn Center, MN (source: City of Brooklyn Center Web site at http://www.ci.brooklyn-center.mn.us/index.asp?Type=GALLERY&SEC=%7B43B99C4C-6141-4D4F-AC75-EB81D0BE1EDF%7D).

A larger study done by Van Metre and Mahler (2005) also showed mostly upward trends in total PAH_{13} concentrations in urban lakes across a range of ecoregions within the United States. Sediment cores were collected from 38 lakes and reservoirs (including the ten lakes and reservoirs sampled in the Van Metre *et al*. 2000 study), age dated, and analyzed for parent and alkylated PAHs, as well as other hydrophobic organic contaminants. The lakes were divided into three groupings depending on land usage in the watershed: dense urban, light urban, and reference (no or very little urbanization). Trends in the concentrations of total PAH_{13} and nine individual PAHs were tested statistically for the following time periods: approximately 1970 to the top of the core, representing 1996 to 2001. The statistical PAH concentration trend was assigned for each lake. Increasing total PAH_{13} trends occurred in 42% of the study lakes, particularly in lakes with urbanized watersheds (Table 11). This increase was attributed to combustion sources. For example in Palmer Lake, sediment samples showed rapid increases in total PAH_{13} concentrations from 1,190 µg/kg dry wt. in 1970 to 16,100 µg/kg dry wt. in the 1990s. Only five percent of lakes showed a decreasing trend in total PAH_{13}. The reference lakes had no statistically significant trend in total PAH_{13} concentrations, but displayed some trends with individual PAHs (Table 11).

Table 11. Summary of Trend Results for Total $PAHs_{13}$ and 3 PAH Compounds in Lake Sediment Samples (n=38; Van Metre and Mahler 2005)

		Percentage of Lakes with Trend of Indicated Type		
Parameter	**Land-Use Setting**	**Increasing**	**Decreasing**	**No Trend**
Total $PAHs_{13}$	All Lakes	42	5	53
	Dense Urban Lake	50	7	43
	Light Urban Lake	53	6	41
	Reference Lake	0	0	100
Phenanthrene	All Lakes	34	11	55
	Dense Urban Lake	36	14	50
	Light Urban Lake	47	6	47
	Reference Lake	0	14	86
Fluoranthene	All Lakes	45	8	47
	Dense Urban Lake	43	0	57
	Light Urban Lake	59	6	35
	Reference Lake	14	29	57
Benzo[a]pyrene	All Lakes	58	8	34
	Dense Urban Lake	57	0	43
	Light Urban Lake	76	6	18
	Reference Lake	14	29	57

Van Metre and Mahler (2005) also examined the magnitude of change in contaminant concentrations over time (Table 12). Twenty-eight of the 38 lakes showed increases in decadal-mean concentrations of total $PAHs_{13}$, and the median percent change in concentrations for individual lakes increased by 41% (Table 12). PAH concentrations were greatly associated with urban land uses.

Table 12. Summary of Decadal-Mean Concentrations for Total PAH_{13} in Lake Sediment Samples (n=38; Van Metre and Mahler 2005)

		Median of Decadal Mean Concentration (µg/kg dry wt.)		
Parameter	**Land-Use Setting**	**1965-1975**	**1990-top of core**	**Median Percent Change Among Lakes Over Time**
Total $PAHs_{13}$	All Lakes	1100	3400	41
	Dense Urban Lake	9000	8900	74
	Light Urban Lake	620	1300	76
	Reference Lake	200	320	0

Stormwater Ponds

South Carolina: stormwater pond sediments

A study of 16 stormwater ponds and two reference ponds in coastal South Carolina suggests that most commercial stormwater ponds, and fewer residential and golf course ponds, are moderately contaminated with PAHs in the surface sediments of this state (Table 13; Weinstein *et al*. 2009). Land use, drainage area, and to a lesser extent, pond surface area, accounted for variation in PAH concentrations. Several PAH forensic methods were used to provide general observations that the majority of PAHs were from pyrogenic sources, although many ponds also had a petrogenic signature (as indicated by the ratios of phenanthrene/anthracene).

Table 13. Ranges of PAH Concentrations Found in Coastal Stormwater Pond Sediments in South Carolina (Weinstein *et al*. 2009)

Analyte	Reference (mg/kg dry wt.)	Golf Course (mg/kg dry wt.)	Residential Low Density (mg/kg dry wt.)	Residential High Density (mg/kg dry wt.)	Commercial (mg/kg dry wt.)
$\sum PAH_{16}$	0.101 – 2.85	0.299 – 6.72	0.186 – 32.1	0.393 – 2.22	0.105 – 159.0
∑LPAHs	0.079 – 1.88	0.190 – 1.72	0.106 – 1.85	0.150 – 0.653	0.079 – 19.0
∑HPAHs	0.023 – 1.25	0.108 – 5.45	0.080 – 30.3	0.144 – 1.57	0.026 – 140.0

South Carolina does not require stormwater pond sediments to be tested for chemical contaminants prior to sediment removal (Weinstein *et al*. 2009). Based upon the results of this study, Weinstein *et al*. (2009) recommended that sediment removed from commercial ponds, as well as residential ponds with large drainage basins should be tested for PAH concentrations prior to removal to determine the most appropriate methods for sediment disposal to reduce ecological risk. Another recommendation made from this study that should be considered with stormwater ponds in Minnesota is to take steps to reduce the outflow of resuspended sediments during sediment removal actions. This step could be accomplished using silt curtains and would help protect downstream biota from exposure to resuspended PAHs.

In another study of brackish low density residential stormwater ponds in coastal South Carolina, false dark mussels (*Mytilopsis leucophaeata*) were used as potential biomonitors of PAHs (Flemming *et al*. 2008). Total PAH_{16} concentrations in all three pond sediments were low at less than 0.2 mg/kg dry wt. False dark mussels bioaccumulated PAH profiles similar to the sediment samples, and their PAH concentrations were less variable than either stormwater or sediment samples. Thus, these organisms may be a promising indicator species for detecting PAH contamination of coastal stormwater ponds.

Minnesota: stormwater pond sediments

Metro area study

Sediments from ten sites within the Twin Cities metropolitan area, including stormwater ponds and natural ponds and lakes that receive storm sewer discharges, were sampled and analyzed for a suite of nutrients and contaminants of potential concern (Polta *et al*. 2006). A total of 43 PAH compounds were analyzed, including alkylated PAHs. The addition of 13 LPAHs and HPAHs yielded total PAH_{13} concentrations in the range of 0.2 - 65.8 mg/kg dry wt., with an average of 11.0 mg/kg dry wt. Four HPAHs (i.e., fluoranthene, pyrene, benzo[a]pyrene, and chrysene) accounted for about 67% of the total PAH_{13} concentrations. When total PAHs were expressed as B[a]P equivalents, benzo[a]pyrene concentrations ranged from 0.19 to 7.28 mg/kg dry wt. Using these data, half of the ponds failed to meet the Tier 1 SRV for B[a]P equivalents.

The results of ten-day *Hyalella azteca* and ten-day *Chironomus tentans* toxicity tests at two of the sites indicated no toxicity to *C. tentans* and slight to moderate toxicity to *H. azteca* at one site (Polta *et al*. 2006). However, it was not reported whether this toxicity was statistically significant.

White Bear Lake stormwater pond study

In 2007, Braun Intertec collected sediment samples from Lily Lake Pond and Varney Pond in White Bear Lake, MN and analyzed them for PAHs, arsenic, and copper (Gionfriddo and Bratrud 2007). Both of these lakes are used as stormwater ponds, and the City of White Bear Lake plans on improving them in the near future. For both lakes, none of the individual PAH compounds exceeded their respective Level 1 SRV. However, the B[a]P equivalent exceeded the Level 2 SRV for two sediment samples from Varney Pond which placed these sediments in the Level 3 dredged material classification per MPCA guidance for managing dredged material (Stollenwerk *et al*. 2009). The B[a]P equivalent was less than the Level 1 SRV for the sediment samples from Lily Lake.

The City of White Bear Lake, MN postponed dredging of Varney Lake due to dredging costs in excess of $500,000 (Brent Thompson, City of White Bear Lake, personal communication to Amy Garcia, MPCA, on April 17, 2009). Sediments from this stormwater pond exceed the MPCA's Level 3 dredged material classification and must be disposed of in a lined landfill. The City is awaiting the results of a MPCA funded study by the University of Minnesota regarding whether compost can be used to further biodegrade PAHs to acceptable levels for land disposal; additional information about this study is provided in the next chapter.

The City of White Bear Lake is intending to excavate the sediment from Lily Lake sometime within the next year (Brent Thompson, City of White Bear Lake, personal communication to Amy Garcia, MPCA, on April 17, 2009). The city reconstructed the streets near this pond during the summer of 2009.

MPCA stormwater pond study

The MPCA collected sediment samples from Twin Cities metropolitan area stormwater ponds during October 2009, as an economical way to gather information that will be applicable throughout greater Minnesota (Figure 17). This study is being conducted to support coal tar legislation enacted into law in Minnesota during May 2009 (see the next chapter for additional information). Fifteen ponds in the MS4 program were selected for this study, including five from each of the following major landscape categories: residential, commercial, and industrial land uses. Minnesota Public Radio did a story on the field sampling component of this study, which is provided in Appendix E.

This study has the following objectives:

- Determine the influence of urban watershed land uses (i.e., residential, commercial, and industrial) on PAH concentrations, as well as other measured contaminants, in stormwater pond sediments, including:
    - Carcinogenic PAHs, as well as parent and alkylated PAHs;
    - Eighteen metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc), mercury, and chloride;
    - Semivolatile organic compounds (SVOCs); and
    - Total organic carbon (TOC), black carbon, and particle size.
- Determine the applicability of an analytical screening technique (i.e., laser induced fluorescence), as well as simple chemical modeling, for conducting sediment assessments of stormwater pond sediments;
- Determine whether some emerging contaminants are present at detectable concentrations in metro area stormwater pond sediments, including:
    - Perfluorochemicals (PFCs);
    - Polybrominated diphenyl ethers (PBDEs);
    - Synthetic pyrethroids; and
    - Octylphenols, nonylphenols, and nonylphenol ethoxylates.
- Compare applicable data to the MPCA SRVs and SQTs to determine any exceedances;
- Determine contaminants of concern in stormwater ponds; and

- Modify, if needed, the sampling and dredge disposal recommendations for MS4 permittees and other stormwater pond owners.

As of March 4, 2010, all of the sediment chemistry data have been analyzed, and portions of the data set are undergoing a quality assurance/quality control review as noted in Table 14. Staff assistance has been secured to prepare a Microsoft™ Access database of the study results, which will facilitate data analysis. A draft report will be prepared by June 30, 2010. The results will be used to provide guidance to MS4 permittees on possible cost-saving techniques they can use to characterize sediment quality in their stormwater ponds. The results of this study will also be used to develop BMPs. For additional information on this study, contact Judy Crane at judy.crane@state.mn.us.

A. B.

C. D.

Figure 17. Photographs of the MPCA's stormwater sediment sampling survey conducted during October 2009. A) Harold Wiegner and Judy Crane sampling sediments in a pond located in a residential area of Lakeville, MN (photo by Anna Kerr); B) Harold Wiegner and Mike Walerak sampling sediments in a pond located in an industrial area of Lakeville, MN (photo by Judy Crane); C) Target pond in North St. Paul, MN that represented a pond receiving commercial drainage (photo by Jordan Donatell); and D) Harold Wiegner and Mike Anderson sampling sediments at Hampshire Pond in Bloomington, MN , which received industrial drainage (photo by Judy Crane).

Table 14. Status of the Analytical Components of the MPCA's Stormwater Sediment Study

Parameter	# of Samples	Analytical Status	QA/QC Review
Chemical Analyses by MDH			
ICP-MS Scan of 18 Metals	67	Done	In Progress
Mercury	67	Done	In Progress
Chloride	17	Done	In Progress
Percent Moisture	67	Done	In Progress
Chemical Analyses by Pace Analytical			
Carcinogenic PAHs	67	Done	Complete: QA/QC issues have been addressed
TOC	67	Done	Complete: QA/QC issues have been addressed
SVOCs	17	Done	Complete: QA/QC issues have been addressed
Percent Moisture	67	Done	Complete
Chemical Analyses by AXYS			
PFCs	17	Done	Complete
PBDEs	17	Done	Complete
Pyrethroids	17	Done	In progress
Octylphenols, nonylphenols, and nonylphenol ethoxylates	17	Done	Complete
Parent and Alkylated PAHs (Battelle)	20	Done	Complete
Laser Induced Fluorescence (LIF; Dakota Technologies)	67	Done	Complete
Black Carbon (Test America)	67	Done	Complete
Particle Size (UMN-Duluth)	67	Done	Expecting data report by 3/17/2010

MDH = Minnesota Department of Health; ICP-MS = Inductively Coupled Plasma—Mass Spectrometry; PAHs = polycyclic aromatic hydrocarbons; TOC = total organic carbon; SVOCs = semivolatile organic compounds; PFCs = perfluorochemicals; PBDEs = polybrominated diphenyl ethers; LIF = laser induced fluorescence; UMN = University of Minnesota; QA/QC = quality assurance/quality control.

Management Options

Regulations for PAHs

Federal regulations

A thorough summary of regulations and guidelines applicable to PAHs is available on the ATSDR's Web site at: http://www.atsdr.cdc.gov/toxprofiles/tp69-c7.pdf (ATSDR 1995). Due to the human health and environmental concerns that PAHs pose, regulations were established to control their releases, and the U.S. EPA has placed several PAHs on their Priority Chemical List. The Occupational Safety and Health Administration (OSHA) has established worker permissible exposure limit for PAHs. In the Clean Air Act, PAHs are regulated as Air Toxics or Hazardous Air Pollutants, which are pollutants that cause or may cause cancer or other serious health effects. The Clean Water Act also has PAH regulations such as wastewater effluent standards and some watersheds have TMDL impairments for PAHs. Waste materials, such as commercial chemical products, containers, and spill residues that contain certain PAHs, are listed as hazardous waste under RCRA. Despite these established regulations, several gaps exist that allow for releases of PAHs to the environment.

The most likely significant regulatory gap in terms of PAHs is the exemption of coal tar from RCRA, which was established to control the disposal of hazardous waste. The exemption is meant to encourage its use in certain products. A study found commercial coal tar-based sealcoat to be composed of 3.4 – 20% by weight PAHs as compared to 0.03 – 0.66% by weight for asphalt-based sealcoat products (Mahler *et al.* 2005). Despite coal tar being composed of such a large percentage of PAHs, its reuse is considerably simplified by this omission of the Act. This regulatory simplification allows for its use as an ingredient in hair dye, psoriasis skin treatment, and dandruff shampoos (National Toxicology Program 2005). In addition, its use as a major ingredient in coal tar-based sealcoat products is likely made easier by this exemption.

State and provincial regulations

The MPCA has provided general guidance on how to dispose of sediments from construction activities, publicly owned stormwater ponds, and stormwater system grit chambers (MPCA 2000). This guidance does not apply to sediments permitted under NPDES requirements, the State Disposal System permit program, or other pollution control programs. The MPCA regulates the disposal of dredged material via the State Disposal System permit program (Polta 2004). Under this scenario, contaminant concentrations in the dredged material are compared to the MPCA's SRV values to determine any restrictions on the use of dredged material (Stollenwerk *et al.* 2009).

For sediment removed from publicly owned stormwater ponds, the MPCA suggests that dewatered stormwater sediments can be used as daily cover material on landfills (MPCA 2000). However, a more prudent choice would be to use these sediments as a cover on either lined areas of permitted sanitary landfills or demolition landfills that have groundwater monitoring systems. Upland areas may be acceptable for sediment disposal, provided human health exposure routes are avoided (MPCA 2000).

The MPCA funded work by the Metropolitan Council Environmental Services to conduct a survey of regulations used to control the use and disposal of stormwater pond sediments in the U.S. and Canada (Polta 2004). Eleven of the 30 state and provincial agencies that responded to the survey have no process in place for regulating the disposal of stormwater pond sediments. For the other states and provinces that regulate sediment disposal, a variety of approaches were used. Some jurisdictions use narrative statements prohibiting pollution, whereas other agencies have expanded their narratives to include numerical sediment quality guidelines for contaminants of potential concern (Polta 2004).

Local bans on coal tar sealcoat products

Currently, local bans on coal tar sealcoat products have been implemented by: Austin, TX (City Council of the City of Austin 2005); Dane County, WI (County Board of Supervisors of the County of Dane 2007), and Washington, DC (Council of the District of Columbia 2008). A comparison of the features of each ban is provided in Table 15 and copies of the bans are provided in Appendix F. Each ban is similar in that it bans the sale or use of coal tar pavement products. Dane County, WI does not directly use the term "coal tar sealcoat products" but instead uses the phrasing "sealcoat products labeled as containing coal tar." Both Austin, TX and Dane County, WI have labeling requirements at retail locations and require forms to be filled out by purchasers which are recorded by retail establishments.

Table 15. Comparison of Three Local Coal Tar Sealcoat Bans in the United States

Parameter	**Austin, TX**	**Dane County, WI**	**Washington DC**
Date effective	November 28, 2005	July 1, 2007	July 1, 2009
Product definition	*Coal tar pavement product* means a material that contains coal tar and is for use on an asphalt or concrete surface, including a driveway or parking area.	*Sealcoat* is a black liquid that is sprayed or painted on asphalt pavement in an effort to protect and beautify the asphalt. Most sealcoat products are coal tar or asphalt-based.	*Coal tar pavement product* means a material that contains coal tar and is for use on an asphalt or concrete surface, including a driveway or parking lot.
Product user requirements	A person may not use a coal tar pavement product.	No person shall apply any sealcoat product labeled as containing coal tar.	No person shall use, or permit to be used, a coal tar pavement product.
Retail requirement	A person may not sell a coal tar pavement product unless to someone who intends to use the product outside the City's planning jurisdiction and the seller completes a form.	Any person who sells pavement sealcoat shall display specified text explaining the ban. No person shall sell, offer to sell, or display for sale any sealcoat product that is labeled as containing coal tar, except if the purchaser intends to use the product outside of Dane County and completes a form.	No person shall sell or offer for sale a coal tar pavement product.
Retail recordkeeping	Seller must retain forms for at least 3 years.	Seller must retain forms for at least 3 years.	none
Violation penalties	Violators commit a Class C misdemeanor punishable by a fine not to exceed $500; or if the person acts with criminal negligence, a fine not to exceed $2,000 (daily).	Residential violators shall be subject to a $25 fine per violation. All other violators shall be subject to a $50 fine for the first violation within a twelve month period, $150 for the second violation within a twelve month period, and $300 for a third and each subsequent violation within a twelve month period.	Violators shall be liable for a civil penalty in an amount not to exceed $2,500 for each violation (daily).
Usage exemptions	The Director may exempt a person who is conducting research or if a viable alternative is not available.	The Director may exempt a person who is conducting research.	none

The Washington, DC ban is the simplest in requirements and penalty (Table 15). Any person who violates the purchase or use of coal tar sealcoat products may be liable to a civil penalty in an amount not to exceed $2,500 for each violation which can be assessed daily. In Austin, TX, a person in violation commits a Class C misdemeanor punishable by a fine not to exceed $500; or if the person acts with criminal negligence, a fine not to exceed $2,000. Dane County has the most complex penalty, which depends on who is applying the sealcoat and the number of past offenses. A person who violates the Dane County ban shall be subject to a forfeiture of $25 per violation. Any commercial sealcoat product applicator who is in violation shall be subject to a forfeiture of $50 for the first violation within a 12 month period, $150 for a second violation within a 12 month period, and $300 for the third and each subsequent violation within a 12 month period.

The local Environmental Advisory Board for the City Council of Springfield, MO is also considering a ban on coal tar sealcoat products (http://www.news-leader.com/print/article/20100208/NEWS01/2080371/Coal-tar-Who-is-taking-sides). As of February 9, 2010, the City Council has held several meetings on this subject and has had further e-mail discussion on this issue. The Environmental Advisory Board is urging local businesses to use environmental friendly parking lot sealcoats, for which Springfield Striping & Sealing and Residential Sealing Services plans to abandon coal tar sealcoat this season, resulting in a reduction of 200,000 gallons of coal tar sealcoat annually by them. In addition, a fishing store and medical facility plan to not ask for coal tar sealcoats on their parking lots (http://www.news-leader.com/article/20100205/NEWS01/2050330).

Statewide bans on coal tar sealcoat products

Michigan

The State of Michigan is considering a ban on coal tar-based sealant products for concrete, asphalt, or other pavement, with certain exceptions, including:

1. The person is researching the effect of a coal tar product on the environment or is developing an alternative technology, and the use of a coal tar product is required for the research or development.
2. A suitable alternative to the coal tar product is not available for the intended use.

Michigan House Bill Number 5706 was introduced on December 16, 2009 by Representatives Warren, Liss, Tlaib, Donigan, and Scripps to ban coal tar products, and the bill was referred to the Committee on Great Lakes and Environment (House Bill No. 5706 at: http://www.legislature.mi.gov/(S(w55t45jshb2udv550kerrp55))/mileg.aspx?page=GetObject&objectName=2009-HB-5706; Appendix G). As of March 4, 2010, no further action has been taken on this bill.

Minnesota

Representative Bev Scalze (DFL, Vadnais Heights, MN) proposed a ban on coal tar-based sealcoats for use by state agencies in the 2009 Minnesota Legislative session. The components of her bill were eventually incorporated into the Omnibus Cultural and Outdoor Resources Finance Bill (HF Number 1231) which was passed by the Minnesota Legislature on May 18, 2009 (Minnesota Legislature 2009). Governor Tim Pawlenty signed the bill into law on May 22, 2009. The coal tar policy provisions in this Omnibus bill are found within lines 31.19 – 32.3, 51.23 – 51.28, and 56.14 – 57.14 of the bill at: https://www.revisor.leg.state.mn.us/bin/bldbill.php?bill=ccrhf1231.html&session=ls86 (Appendix H). The provisions will:

- Prevent state agencies from purchasing undiluted coal tar sealcoat after July 1, 2010.
- Notify state agencies and local units of government of the potential for contamination of constructed stormwater ponds and wetlands, or natural ponds used for the collection of stormwater via constructed conveyances, with PAHs from the use of coal tar sealcoat products. This notification was made by the January 15, 2010 deadline (Appendix I).
- Establish a schedule for an inventory and information requirements for state agencies and local units of government regulated under a NPDES or MS4 state disposal system permit to report to the Commissioner on all stormwater ponds and other waters defined above and located within their jurisdiction. This task was completed by the January 15, 2010 deadline (Appendix J). Interested persons should check the MPCA Web site for updates and clarifications to this guidance.

- Develop BMPs for state agencies and local units of government regulated under a NPDES or MS4 state disposal system permit to treat or clean-up contaminated sediments in stormwater ponds and other waters defined above and make the BMPs available on the Agency's Web site. As part of the development of the BMPs:
    - Sample a set of stormwater pond sediments in residential, commercial, and industrial areas for PAHs and other contaminants of potential concern (note: this task was completed during October 2009);
    - Investigate the feasibility of screening methods to provide more cost-effective analytical results and to identify which kinds of ponds are likely to have the highest concentrations of PAHs; and
    - Develop guidance on testing, treatment, removal, and disposal of PAH-contaminated sediments.
- Incorporate the requirements for an inventory and BMPs specified above into the next permitting cycle for NPDES and MS4 permits.

This bill provided $155,000 for the first year to provide notification of the potential for coal tar contamination, establish a stormwater pond inventory schedule, and to develop BMPs for treating and cleaning up contaminated sediments, as required. The second year will provide funds to develop a model ordinance for the restricted use of undiluted coal tar sealcoats and to provide grants to local units of government for up to 50% of the costs to implement BMPs to treat or clean-up contaminated sediments in stormwater ponds and other waters as defined under this article (Appendix K). Local governments must have adopted an ordinance for the restricted use of undiluted coal tar sealcoats in order to be eligible for a grant, unless a statewide restriction has been implemented. A grant awarded under this provision must not exceed $100,000 (Minnesota Legislature 2009). The City of White Bear Lake, MN is considering a ban on coal tar-based sealcoat products in order to be eligible for a grant.

For updates on the status of the MPCA's tasks mentioned above, refer to the MPCA's Web page on "Restriction on Coal Tar-based Sealants" at: http://www.pca.state.mn.us/water/stormwater/stormwater-coaltar.html.

Management Options Pertaining to PAH-Contaminated Stormwater Pond Sediments

Many stormwater ponds in Minnesota are over 15 years old and are filling up with sediment that must be removed to maintain their efficiency. The Metropolitan Council Environmental Services (Polta 2001) noted in 2001 that Twin Cities communities have little experience with dredging and disposing of stormwater pond sediment. Polta (2001) developed a rough estimate of the annual rate of sediment accumulated in the metro area as 100,000 to 200,000 tons. Better volume estimates need to be developed based on the design volume of stormwater ponds in the metro area and on the occurrence of any high loading events.

Dredged sediment is usually used as a fill material or placed in a landfill. Some stormwater pond sediments have PAH concentrations that prevent reuse or disposal by means other than at a high cost at one of Minnesota's limited number of lined landfills. Municipalities are requesting guidance from the MPCA on how to best manage stormwater pond sediments that are contaminated with PAHs at high enough concentrations to qualify as Level 3 dredged material. The MPCA's management options can generally be classified as follows:

- Pollution prevention efforts to reduce the use of PAHs in products that could be emitted into stormwater runoff;
- Source control efforts to reduce sources of PAHs to the environment;
- Implementation of BMPs to reduce the transport of PAHs to stormwater ponds;
- Remediation of PAH-contaminated stormwater pond sediments; and
- Adoption of beneficial reuse options for less contaminated sediments, such as zones of cleaner sediments in stormwater ponds or those sediments that have been remediated.

Implementation of a combination of management options may provide the most flexibility and success with addressing this issue.

Pollution prevention strategies

Pollution prevention strategies will reduce or eliminate the use of PAHs in products which may otherwise release PAHs during the life cycle of the product. Pollution prevention is defined in the Minnesota Toxic Pollution Prevention Act (established in 1990) as eliminating or reducing at the source the use, generation, or release of toxic pollutants (Lundquist and Snyder 1999). Methods of reducing pollution include, but are not limited to, industrial process modification, inventory control measures, feedstock substitutions, various housekeeping and management practices, and improved efficiency of machinery (Minnesota Sea Grant; http://www.seagrant.umn.edu/pubs/ggl/p.html#P15).

A limited ban on the use of coal tar sealcoat products by state agencies in Minnesota will go into effect July 1, 2010 (Minnesota Legislature 2009). A broader, statewide ban on coal tar sealcoats would be one of the best pollution prevention strategies to reduce PAH contamination of stormwater ponds. The Minnesota Legislature would need to implement such a ban, in conjunction with the Governor's approval of the ban. In the absence of a statewide ban, municipalities could consider their own bans of coal tar sealcoats like the bans that are in place for Austin, TX; Dane County, WI; and Washington, DC. The MPCA could serve as a technical resource for those municipalities considering a ban. The potential consequences of a ban in Minnesota are most likely to concern suppliers and commercial operators due to potential:

- Increases in costs of operation;
- Reductions in the performance of their operations; and
- Changes in demand for their services.

The MPCA anticipates the cost of materials themselves would not be a significant issue for businesses. The price of sealcoat varies depending on market conditions since the bulk of the product is made from commodities with frequent price changes (i.e., asphalt, a refined petroleum product, and coal tar, a coke production by-product from steel production). A recent price check of asphalt and coal tar-based sealcoats showed exactly the same price of $1,149.00 for a 275 gallon bulk tote (Asphalt Sealcoating Direct at: http://www.asphaltsealcoatingdirect.com/catalog/182/asphalt_products_and_material, visited 3/20/09). In 2006 and 2007, though, there were shortages of coal tar and therefore, coal tar sealcoat shortages. One of the ways the industry compensated was to increase the use of asphalt-based sealcoats (http://www.forconstructionpros.com/publications/article.jsp?pubId=3&id=4081&pageNum=14). This would imply that the industry is adaptable and able to avoid coal tar. The MPCA anticipates there would be no or little performance issues with switching away from coal tar-based sealcoats to asphalt-based ones. The two products are designed for the same purpose, and many consumers already use petroleum-based products. For example, Mn/DOT does not allow for any coal tar-based products in its specifications. Some municipalities in Minnesota are also only using petroleum-based products. For example, Minneapolis Public Works Director Mike Kennedy recently indicated his city has not used coal tar-based sealcoat for years (Thiede 2008; Appendix L).

Source control strategies

Source control efforts would reduce sources of PAHs to the environment. In the absence of statewide or municipal bans on coal tar sealcoat products, the MPCA could either promote the use of asphalt-based sealcoats, encourage no use of sealcoat products, or a combination of these strategies. Other strategies which would reduce the release of pyrogenic (i.e., combustion) PAHs would hold the most benefit. In particular, reductions in vehicular traffic (Ravindra *et al*. 2008), changes in gasoline formulations to reduce PAH emissions (Marr *et al*. 1999), increases in the use of electric-powered vehicles, and reductions in coal fired power plant emissions (Ravindra *et al*. 2008) would reduce sources of PAHs to the environment.

Implementation of BMPs

The implementation of BMPs can be used to reduce the transport of PAHs in stormwater runoff to stormwater ponds, as well as to downstream waterways when ponds begin to fill up and lose their effectiveness. Examples of BMPs are provided in the Minnesota Stormwater Manual (Minnesota Stormwater Steering Committee 2006). Community land use planning that reduces the percentage of impervious cover by creating narrower residential roads etc., that promotes green roofs, and sustainable rainwater harvesting will also reduce the amount of stormwater runoff that could potentially transport PAHs to stormwater ponds.

Stormwater runoff treatment relies upon three primary processes to improve water quality and reduce contaminant loads into rivers and lakes:

- Infiltration (e.g., rain gardens, pervious concrete roadways);
- Filtration (e.g., swales, ditches); and
- Sedimentation for removing sediments that can fill in lakes, generate turbidity impairments and concentrate other contaminants, such as PAHs.

A novel infiltration method being tested in Shoreview, MN involves the use of approximately one mile of pervious concrete streets without storm sewers in the Woodbridge neighborhood on Lake Owasso (Blake 2009). According to Shoreview Public Works Director Mark Maloney, "This is the first complete commitment to using a pervious pavement on a residential street replacement" in Minnesota (Blake 2009). The pervious concrete will allow water to drain straight to the underlying soil. In conjunction with this project, the Ramsey Conservation District will sink four wells when the streets are built so they can monitor how drainage through the pavement affects groundwater quality (Blake 2009).

Swales and ditches can be used to slow the movement of runoff and filter stormwater. Other ways of filtering stormwater are in development. A proprietary stormwater filtration device (i.e., StormFilter) was tested at an asphalt parking lot in downtown Madison, WI, and runoff from the parking lot was tested for a suite of chemicals for 51 runoff events (Horwatich and Bannerman 2008). Use of this filtration device resulted in significant decreases in the loads of constituents in the outlet runoff, including: total suspended solids, suspended sediment, volatile suspended solids, total phosphorous, total copper, total zinc, and PAHs (Horwatich and Bannerman 2008).

Typical suspended sediment removal (and hence sediment accumulation) relies upon structural BMPs such as dry ponds, wet ponds, engineered wetland treatment areas, and underground trapping devices. The addition of sediment forebays can increase the settling area for incoming sediments, although it is only recommended for wet ponds larger than 4,000 cubic feet (Barr Engineering Company 2001). The MPCA is a member of the Minnesota Stormwater Steering Committee, and this group could be engaged to provide recommendations on the best combination of BMPs to reduce the transport of PAHs to stormwater ponds. In doing so, an effort needs to be made to not just transfer the problem elsewhere (e.g., reducing PAHs in stormwater ponds, but increasing loads of PAHs to rain gardens).

In addition to sedimentation, some researchers have conducted pilot-scale field tests to reduce the aqueous phase of PAHs entering stormwater ponds from inflow and resuspended sediments. Boving and Neary (2007) used filters made of aspen wood cuttings contained in mesh bags and suspended across a pond perpendicular to the flow direction. Overall, they found the average filter effectiveness for total $PAHs_{10}$ ranged from 18.5 to 35.6%, and filters containing more wood mass were more effective at removing PAHs. The wood filter was also more effective at removing HPAHs than LPAHs, probably due to partitioning to wood fibers. Additional work with the filter design is needed to reduce contaminant remobilization under high flow conditions.

Remediation options

Dredging and land application

Stormwater pond owners are responsible for periodically removing sediments from their ponds. The most common disposal option is to land apply dredged material. The sediment must meet the specifications the MPCA has set forth for Level 1 or Level 2 dredged material in order to land apply it (Stollenwerk *et al*. 2009).

Although PAHs and other contaminants may be resuspended into the overlying water during dredging actions, best management practices can be used to reduce resuspension by:

- Draining off the overlying water prior to dredging;
- Dredging the sediment during the winter when the overlying water is frozen; and
- Setting up silt curtains at the inlet and outlet of the ponds to reduce the transport of resuspended sediments during dredging.

Disposal in specially lined landfills

Minnesota has a limited number of lined landfills that could accept Level 3 dredged material. The creation of new lined landfills would probably not solve the problem due to the volume of sediments which must be disposed of as Level 3 dredged material.

Bioremediation of PAH-contaminated sediments using compost

Australian researchers have lowered PAH concentrations in coal tar contaminated soils by mixing the soil with compost, thereby providing a better environment for microbial degradation of PAHs to nontoxic components (Guerin 2000; Atagana *et al*. 2003). In order to access whether this technique can be applied to stormwater pond sediments in a northern climate, the MPCA is currently funding a project by Professor's John Gulliver and Ray Hozalski of the University of Minnesota's Department of Civil Engineering to carry-out a two-phase bioremediation study. In the first phase, a bench-scale system of 48 treatment containers was designed to optimize the sediment-to-compost and nitrogen-to-carbon ratios under controlled temperature and relative humidity conditions. A second, bench-top in-vessel compositing bioremediation system of four compost piles was also designed to simulate a full scale composting pile and to create the correct conditions for bioremediation of PAHs in sediments. The temperature on the edge of the vessels is set by the middle pile temperature, and the ability of a mixture to create the temperature conditions necessary to biodegrade PAHs is determined. The degradation of a suite of 30 PAHs will be evaluated. In the second phase (pending funding), a full scale composting of PAH-contaminated sediments will be initiated and evaluated for successful remediation, in cooperation with metro area compost companies. Results are not yet available for this study, but a recent project presentation by the University of Minnesota team is available in Appendix M. Further information about this project can be obtained by contacting Professor John Gulliver at gulli003@umn.edu.

Minnesota Mulch and Soil, a specialty soil, wood, and compost recycling company, obtained a beneficial use permit from the MPCA in the winter of 2008 to treat Tier 1 dredged material with yard waste and compost for reuse in Mn/DOT projects (Minnesota Mulch and Soil Web page: http://mnmulchandsoil.com/MnMulchandSoil_97-2003.pps). The dredged material came from Kohlman Creek in Maplewood, MN, and treatment with compost resulted in the reduction of lower concentration Level 2 dredged material to Level 1 dredged material. However, it is not clear whether this reduction was due to reduction of PAH compounds or to a dilution effect from adding compost to the dredged material.

Beneficial reuse options for dredged sediment

Dredged material containing low concentrations of contaminants could be used in aquatic areas for beneficial uses such as beach nourishment projects, shoreline stabilization, habitat creation, and habitat restoration. These types of projects are currently done with dredged material from the navigation channels of the Duluth-Superior Harbor. However, to be feasible for stormwater pond sediments, there would need to be cost-effective ways to compile and transport clean dredged material for aquatic beneficial uses. For these types of projects, the MPCA's Level I and Level II SQTs could be used for guidance. Since sediments often contain a mixture of contaminants, the mean probable effect concentration quotients (PEC-Qs) could be used as cutoff triggers as to whether the sediment could be placed in water bodies near sensitive areas (e.g., parks, residential areas), commercial/industrial waterways, or not used at all. For example, a mean PEC-Q of 0.1 could be used as the upper-bound of dredged material quality allowed in water bodies by sensitive areas, and a mean PEC-Q of 0.6 could be used as the upper-bound of dredged material quality allowed in commercial/industrial waterways. Additional discussion by MPCA management will be needed on this issue for any policy decisions.

For upland beneficial reuses of dredged material, there has been a great deal of work done in this regard in the Great Lakes area and at coastal ports around the world. In particular, the Great Lakes Commission (Pebbles and Thorp 2001) has summarized a number of upland beneficial reuses of dredged material, as follows:

- Landscaping;
- Topsoil creation or enhancement;
- Road construction;
- Land creation or reclamation (e.g., strip mines, brownfields); and
- Manufacture of aggregates for marketable products, such as ceramics or asphalt.

In the Duluth-Superior Harbor area, dredged material from the harbor is being recycled at the Erie Pier Confined Disposal Facility in Duluth, MN using a soil washing process to separate sediment particles by size (Pebbles and Thorp 2001). The coarser (i.e., cleaner material) is used for a number of beneficial uses. A centralized soil washing facility in the Twin Cities metropolitan area could provide a way to beneficially reuse some of the dredged material removed from stormwater ponds. Factors that would affect implementation of a soil washing facility include: state and federal laws and regulations, costs, and physical and chemical properties of the material.

Researchers in France designed a pilot plant based on sieving and attrition (i.e., friction) to treat stormwater sediments (Pétavy *et al*. 2007, 2009). In their system, which can potentially be done *in situ* at a stormwater pond, the sediments were processed so that most of the pollutants were concentrated in the fine fraction. Up to 75% of the bulk sediment could be beneficially reused.

Recommendations

In order to move forward on addressing the problem of PAH-contaminated stormwater pond sediments and to provide municipalities with guidance, the MPCA recommends the following actions:

- Educate the public and stakeholders about pollution prevention strategies that will reduce or eliminate the use of PAHs in sealcoat products applied to driveways and parking lots. The following activities will help accomplish this task:
    - Distribute a fact sheet for homeowners on environmental concerns of coal tar-based sealcoats (Appendix N);
    - Prepare a fact sheet on this report to share with municipal stormwater staff, sealcoat contractors, environmental groups, and other stakeholders;
    - Hold informational meetings with interested stakeholders;
    - Provide educational information at environmental fairs such as the Living Green Expo and the EcoExperience at the Minnesota State Fair; and
    - Submit articles to trade journals and scientific journals on this issue.
- Monitor the University of Minnesota's progress with conducting a two-phase bioremediation study using compost to assess microbial degradation of PAHs in stormwater pond sediments. Facilitate activities that will benefit this study;
- Implement the coal tar policy provisions passed in the 2009 legislative session. A work plan for these legislative tasks was prepared by the MPCA (Crane and Cherryholmes 2009). The remaining tasks of this legislation include:
    - State agencies restricted July 1, 2010: State agencies may not purchase undiluted coal tar-based sealant after this date.
    - Develop best management practices: The MPCA must develop and make available best management practices that can avoid or mitigate environmental impacts of coal tar-based sealcoats.
    - Develop grant process: The MPCA will develop a process by July 2010 for awarding grants to local units of government for treatment of contaminated sediment. The ordinance must be in place to apply for a grant. An announcement will be posted on the MPCA's Web site when applications can be submitted.
    - Updates on these tasks will be available from the MPCA's Web site on Restriction on Coal Tar-based Sealants at: http://www.pca.state.mn.us/water/stormwater/stormwater-coaltar.html.
- Provide technical support to municipalities and/or Legislators who are seeking to ban the use of coal tar-based sealcoats on a local or statewide basis;
- Examine data collected by the University of Minnesota, on behalf of the MPCA, for operation and maintenance surveys of stormwater ponds. These data may be used by the MPCA to identify more efficient BMP practices, as well as to determine the costs associated with operating and maintaining stormwater ponds.
- Evaluate the distribution of sand, silt, and clay in stormwater pond sediments from data compiled by the MPCA. This information can be used to guide beneficial reuse and remediation options.
- Evaluate mapping of stormwater ponds by municipalities for pollutant tracking and emergency response for use by the MPCA's Stormwater Program;
- Consider ways to account for the number of privately owned and unregulated publicly-owned stormwater ponds in Minnesota through the MPCA's survey project with the University of Minnesota and by extraction of data gathered by the MPCA's MS4 permit program; and
- Reduce the outflow of resuspended sediments during sediment removal actions through the use of silt curtains and/or other BMP practices.

For further information about these recommendations, please contact:

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Appendix A: St. Paul Pioneer Press News Story on Stormwater Pond Sediments in White Bear Lake, MN

from September 10, 2008 edition of the St. Paul Pioneer Press:

Aging stormwater retention ponds trouble suburbs, homeowners and scientists

By Elizabeth Mohr emohr@pioneerpress.com

Article Last Updated: 09/10/2008 07:12:43 AM CDT

Costello's home overlooks Lily Lake Pond, a stormwater retention basin surrounded by homes and a stone's throw from White Bear Lake. The pond has become polluted from runoff containing elements such as arsenic and slowly is filling with sediment.

What is happening in 50-year-old Lily Lake Pond is occurring in stormwater retention ponds across the metro area. And until now, such ponds went largely unmonitored.

Residents like Costello, who do not want to see their back yards become mud pits or dry valleys, have begun contacting city officials, demanding something be done.

Stormwater retention ponds "were state-of-the-art things to do 30 years ago," said Anna Kerr, who reviews municipal stormwater management for the Minnesota Pollution Control Agency. But scientists are finding out that's the average lifespan of the ponds, she said.

"Now is the first time most of them need to be dredged," Kerr said.

When the ponds became popular during the suburban boom several decades ago, they were thought of primarily as a means to control flooding in new developments. But they also act as catch basins or filters, collecting sediment and runoff pollutants from roads and lawns before the water reaches larger bodies of water.

Lily Lake Pond feeds White Bear Lake, which is in the Mississippi River basin, draining into the riverway that eventually flows to the Gulf of Mexico.

EXPENSIVE SOLUTIONS

Costello and his neighbors petitioned White Bear Lake officials last year to take a look at the city's stormwater ponds.

Hired to do the testing, Braun Intertec found many ponds had deep sediment deposits and high levels of arsenic, copper and other potentially harmful pollutants. Lily Lake Pond and Varney Lake Pond raised the most concern.

In Varney Lake Pond, a sand island is permanently visible in one corner, near a storm drain, and sand depths were 23 inches in other spots. Sediment in Lily Lake Pond reached 33 inches in some spots and was too deep to measure in others. Pollutants in both exceeded the MPCA's recommended levels.

White Bear Lake officials decided in 2007 to dredge the ponds, but the work has yet to begin.

The city is grappling with how to pull it off logistically and financially, White Bear Lake public works director Mark Burch said.

Several permits are needed to drain and dredge a pond. Many ponds were built without access for the large machinery to do the work. And once the material is extracted, getting rid of it can be expensive.

"This is a huge, huge project to undertake," Burch said. A December city memo estimated the cost to clean both ponds at nearly $250,000.

White Bear Lake officials are working with the MPCA on dredging options.

The MPCA has a set of guidelines for dredging lakes and rivers, but those rules "aren't necessarily appropriate for stormwater ponds," Kerr said.

Her agency is investigating the issue, looking for alternatives to simply dumping the material.

"Ideally, we're trying to find a more creative way to reuse the material," Kerr said. "We have to consider human health and other environmental issues."

BETTER OPTIONS

Dredged sediment is usually processed at a hazardous waste facility or incinerated.

Because of the issues revealed in White Bear Lake, a University of Minnesota researcher is looking for better options.

John Gulliver, a professor in the department of civil engineering, has been studying stormwater management for several years. He has launched a research project on disposing of the polluted sediment.

"You can reduce those (pollutants) basically through a biological process," much like a backyard compost pile, Gulliver said.

For the research project, dredged material will be taken to a composting facility, where it will be mixed with bacteria, fungi and organic compounds, such as wood chips.

Piles of the mixture will be monitored and turned as necessary, allowing the bacteria and fungi to break down the pollutants.

He expects to have test results by next year.

POLLUTION PROTECTION

The situation in White Bear Lake highlights concerns about the stormwater retention ponds across the metro area. What happens to the ponds is largely unregulated, whereas Minnesota rivers and lakes are closely monitored.

Stormwater management practices and the regulation of developers are consistently under review, but officials still are looking for ways to protect the ponds.

A major concern is reducing pond pollution, residents and officials say. Because pollutants come from a variety of sources, efforts to decrease them come from all directions.

The MPCA is studying driveway sealants, which could be a major source of runoff pollutants, Kerr said. Officials are considering a ban in Minnesota on certain sealants deemed most harmful. Only two places in the country — Dane County, Wis., and Austin, Texas — have adopted such measures.

Cities are required to develop Stormwater Pollution Prevention Programs to be submitted to the MPCA each year. As part of the effort, cities must cite what they are doing to limit runoff pollution and how they are regulating their residents. Each year, the requirements tighten.

Efforts also range from encouraging homeowners to build rain gardens to mandating that developers use more environmentally friendly materials.

While Costello supports efforts to help keep the water clean, he worries about a planned street project on his block in a few years. Stringent runoff regulations will guide the construction but may mean even less water in the pond behind his home.

"Stormwater runoff is a mixed blessing for us," Costello said. "It clogs our pond with sediment and causes occasional floods, but we also rely on it to maintain the water levels required for our enjoyment of the pond: pond hockey, paddleboats, canoes, wildlife and beautiful reflections."

Elizabeth Mohr can be reached at 651-228-5162.

Appendix B: Sediment Quality Targets (SQTs) Used by the MPCA

Table B-1. Recommended Level I and Level II Sediment Quality Targets (SQTs) for the Protection of Sediment-dwelling Organisms (Crane *et al*. 2000, 2002)

	Aquatic Life		
Chemical	**Level I SQT**	**Level II SQT**	**Source**[†]
Metals (in mg/kg DW)			
Arsenic[§]	9.8	33	MacDonald *et al*. (2000)
Cadmium*[§]	0.99	5.0	MacDonald *et al*. (2000)
Chromium[§]	43	110	MacDonald *et al*. (2000)
Copper*[§]	32	150	MacDonald *et al*. (2000)
Lead*[§]	36	130	MacDonald *et al*. (2000)
Mercury	0.18	1.1	MacDonald *et al*. (2000)
Nickel[§]	23	49	MacDonald *et al*. (2000)
Zinc*[§]	120	460	MacDonald *et al*. (2000)
PAHs (in µg/kg DW)			
2-Methylnaphthalene	20	200	CCME (1999)
Acenaphthene	6.7	89	CCME (1999)
Acenaphthylene	5.9	130	CCME (1999)
Anthracene*	57	850	MacDonald *et al*. (2000)
Fluorene	77	540	MacDonald *et al*. (2000)
Naphthalene*[§]	180	560	MacDonald *et al*. (2000)
Phenanthrene*[§]	200	1200	MacDonald *et al*. (2000)
Benz[a]anthracene*[§]	110	1100	MacDonald *et al*. (2000)
Benzo[a]pyrene*[§]	150	1500	MacDonald *et al*. (2000)
Chrysene*[§]	170	1300	MacDonald *et al*. (2000)
Dibenz[a,h]anthracene	33	140	MacDonald *et al*. (2000); CCME (1999)
Fluoranthene*	420	2200	MacDonald *et al*. (2000)
Pyrene*[§]	200	1500	MacDonald *et al*. (2000)
Total PAHs*[§]	1600	23000	MacDonald *et al*. (2000)
PCBs (in µg/kg DW)			
Total PCBs*[§]	60	680	MacDonald *et al*. (2000)
Pesticides (in µg/kg DW)			
Chlordane*	3.2	18	MacDonald *et al*. (2000)
Dieldrin*	1.9	62	MacDonald *et al*. (2000)
Sum DDD*	4.9	28	MacDonald *et al*. (2000)

Table B-1. Continued

Chemical	Aquatic Life		
	Level I SQT	Level II SQT	Source[†]
Pesticides (continued)			
Sum DDE*[§]	3.2	31	MacDonald *et al*. (2000)
Sum DDT*	4.2	63	MacDonald *et al*. (2000)
Total DDT*	5.3	570	MacDonald *et al*. (2000)
Endrin	2.2	210	MacDonald *et al*. (2000)
Heptachlor epoxide*	2.5	16	MacDonald *et al*. (2000)
Lindane (gamma-BHC)	2.4	5	MacDonald *et al*. (2000)
Toxaphene	0.1	32	NYSDEC (1999)[¥]
Mean PEC-Q	0.1	0.6	USEPA 2000

SQT = sediment quality target; PEC-Q = probable effect concentration quotient; DW = dry weight.

[†] Some SQT values were rounded to two significant figures from the original source.
* Reliable consensus-based threshold effect concentration (TEC) values that were adopted as Level I SQTs [i.e., predictive ability ≥75% and ≥20 samples below the TEC (MacDonald *et al.* 2000)].
[§] Reliable consensus-based probable effect concentration (PEC) values that were adopted as Level II SQTs [i.e., predictive ability ≥75% and ≥20 samples predicted to be toxic (MacDonald *et al.* 2000)].
[¥] originally based on µg/g organic carbon; assumed total organic carbon (TOC) = 1%.

Table B-2. Additional Recommended Level I and Level II SQTs for Chemicals of Interest (Crane and Hennes 2007)

Chemical	Aquatic Life		
	Level I SQT	Level II SQT	Source
Polychlorinated dibenzo-p-dioxins/ dibenzo furans (in ng TEQ/kg DW)			
PCDD/Fs*	0.85	21.5	CCME 1999

SQT = sediment quality target; TEQ = toxic equivalent; DW = dry weight.
* Values are expressed as TEQ units, based on van den Berg *et al.*'s (1998) toxic equivalency factor (TEF) values for fish. There is currently insufficient information to determine TEFs for invertebrates

Appendix C: Soil Reference Values (SRVs) Used by the MPCA

Table C-1. Dredged Material Soil Reference Values for PAH Compounds (adapted from Stollenwerk *et al*. 2009)

Parameter	Level 1 SRV (mg/kg dry wt.)	Level 2 SRV (mg/kg dry wt.)
PAHs		
Naphthalene	10	28
Pyrene	890	5,800
Fluorene	850	4,120
Acenaphthene	1,200	5,260
Anthracene	7,880	45,400
Fluoranthene	1,080	6,800
Benzo[a]pyrene (B[a]P)/B[a]P equivalent	2	3
*Benzo[a]anthracene	*Dibenz[a,h]anthracene	*3-Methylcholanthrene
*Benzo[b]fluoranthene	*7H-Dibenzo[c,g]carbazole	*5-Methylchrysene
*Benzo[j]fluoranthene	*Dibenzo[a,e]pyrene	*5-Nitroacenaphthene
*Benzo[k]fluoranthene	*Dibenzo[a,h]pyrene	*1-Nitropyrene
*Benzo[a]pyrene	*Dibenzo[a,i]pyrene	*6-Nitrochrysene
*Chrysene	*Dibenzo[a,l]pyrene	*2-Nitrofluorene
*Dibenz[a,j]acridine	*1,6-Dinitropyrene	*Quinoline
*Dibenz[a,h]acridine	*1,8-Dinitropyrene	
*7,12 Dimethylbenz-anthracene	*Indeno[1,2,3-cd]pyrene	

* The results for these analytes should be added together and treated as the B[a]P equivalent, which is compared against the soil reference value for benzo[a]pyrene.

Appendix D: PAH Data from the St. Louis River Area of Concern

Table D-1. Statistical Summary of Sediment Chemistry Values in Surficial Sediments (0 - 30 cm, inclusive) of the St. Louis River AOC (Crane 2006)

Chemical	N	Mean	Standard Deviation	Minimum	10th Percentile*	Median*	90th Percentile*	Maximum
PAHs (µg/kg dry wt.)								
2-Methylnaphthalene	361	15655	134434	1.1	*20.8*	***230***	***5502***	2063492
Acenaphthene	616	2438	14832	0.05	6.2	*59.7*	***2390***	220000
Acenaphthylene	632	4810	59931	0.12	*6.5*	*46.9*	***1653***	1100000
Anthracene	668	8174	61784	1.4	14.7	*230*	***6061***	1100000
Fluorene	662	6240	58315	0.5	9.4	*136*	***3932***	1100000
Naphthalene	566	91781	734115	0.5	28.1	*240*	***16593***	10793650
Phenanthrene	674	18691	150123	3.7	42.2	*619*	***11779***	3000000
Benzo[a]anthracene	671	7721	44253	3.5	35.0	*616*	***8380***	780000
Benzo[a]pyrene	677	5657	34063	3.5	36.2	*500*	***6864***	630000
Chrysene	675	6981	39236	5	49.0	*649*	***7800***	720000
Dibenzo[a,h]anthracene	628	627	2437	0.2	13.0	*75*	***1159***	30645
Fluoranthene	677	16295	101268	6.2	78.6	*1100*	***16244***	1800000
Pyrene	677	12048	71115	5.6	70.2	*1000*	***12510***	1300000
Total $PAHs_{13}$ (exclude high ND)	677	173760	1198126	35.0	448	*5930*	***102908***	18891000
HPAHs (exclude high ND)	677	49196	289402	28.3	285	4249	48937	5230000
LPAHs (exclude high ND)	674	125118	973643	6.7	124	1431	51805	13661000

* Values in italics and yellow shading exceed the corresponding Level I SQT; values in bold italics and orange shading exceed the corresponding Level II SQT.

Table D-2. Statistical Summary of Sediment Chemistry Values in Subsurface Sediments (>30 cm, inclusive) of the St. Louis River AOC (Crane 2006)

Chemical	N	Mean	Standard Deviation	Minimum	10th Percentile*	Median*	90th Percentile*	Maximum
PAHs (µg/kg dry wt.)								
2-Methylnaphthalene	342	15621	127213	0.13	16.5	***320***	***8214***	2230769
Acenaphthene	380	11366	76051	0.19	*11.3*	***240***	***9800***	1269231
Acenaphthylene	388	2276	10696	0.045	*8.5*	*117*	***2598***	132000
Anthracene	399	11775	56899	0.19	16	*497*	***21416***	923077
Fluorene	397	10131	59689	0.19	11.2	*330*	***12993***	1038462
Naphthalene	390	130433	821923	0.31	15	***661***	***96000***	12307692
Phenanthrene	402	33092	160663	0.4	28.3	*1170*	***55300***	2576923
Benzo[a]anthracene	400	10863	32599	0.19	21.5	*800*	***26933***	342308
Benzo[a]pyrene	404	7043	22185	0.11	30.8	*540*	***15060***	253846
Chrysene	402	9795	29954	0.19	23.4	*775*	***23000***	311538
Dibenzo[a,h]anthracene	390	1150	3208	0.07	8.5	*71*	***2311***	31250
Fluoranthene	404	26160	93033	0.4	40.2	*1485*	***62004***	1192308
Pyrene	404	20111	63713	0.4	40.0	*1235*	***45268***	692308
Total $PAHs_{13}$ (exclude high ND)	404	281453	1405778	4.9	313	***11475***	***564633***	23204615
HPAHs (exclude high ND)	404	74927	239856	2.4	214	5155	176426	2804615
LPAHs (exclude high ND)	402	207555	1219157	2.4	129	4426	226871	20400000

* Values in italics and yellow shading exceed the corresponding Level I SQT; values in bold italics and orange shading exceed the corresponding Level II SQT.

Table D-3. Summary of Phenanthrene/Anthracene (P/A) and Fluoranthene/Pyrene (FL/PY) Ratios for Selected Depth Intervals in the St. Louis River AOC (Crane 2006)

Depth Interval (cm)	N	P/A			F/P		
		Mean	SD	Median	Mean	SD	Median
St. Louis River AOC							
0 - 30 cm, inclusive	669	3.12	1.87	2.69[a]	1.18	0.69	1.17[b]
>30 cm, inclusive	399	3.07	3.57	2.46[a]	1.17	0.25	1.17[b]
Other depth intervals	273	2.73	2.1	2.15	1.21	0.87	1.12
Post-remediation St. Louis River AOC*							
0 - 30 cm, inclusive	506	2.88	1.54	2.48[c]	1.28	0.75	1.23[d]
>30 cm, inclusive	357	3.05	3.74	2.38[c]	1.19	0.23	1.19[d]
Other depth intervals	231	2.53	1.89	2.11	1.26	0.92	1.14

* Excluded the pre-remediation P/A and FL/PY data from Hog Island Inlet/Newton Creek.

[a] The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (p = 0.024).

[b] The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (p = 0.678).

[c] The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (p = 0.353).

[d] The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (p=0.003)

Appendix E: Minnesota Public Radio Story

From: http://minnesota.publicradio.org/display/web/2009/10/29/sealant-runoff#

New concerns raised over blacktop sealant runoff

by Tim Nelson, Minnesota Public Radio

November 2, 2009

St. Paul, MN — A long-standing ritual of homeowners - sealing their blacktop driveways - is getting new scrutiny from the state of Minnesota because sealant from driveways and parking lots may be washing off into ponds and streams as hazardous waste.

About 30 years ago, environmental regulators had an idea: they could keep ground water cleaner by damming up runoff from streets, parking lots and other places, and letting pollutants settle out before the water ran into lakes and streams.

Stormwater retention ponds started showing up all over the place, and they work. There are now about 20,000 of them in the Twin Cities. Trouble is they work a little too well, as they were meant to collect contaminants like fertilizer runoff.

Dale Thompson runs the Minnesota Pollution Control Agency's Municipal Stormwater Unit and was helping test a pond off Tahoe Road in Woodbury.

"Probably it's only recently that we started to get a little concerned about everything else that might be going along with the typical nitrogen and phosphorus that we would expect to be in and the particles, and the sand and grit that we would expect to be coming off the roads," Thompson said. "We started to see some other things showing up."

One of those things is PAH, or polycyclic aromatic hydrocarbons. They're formed during combustion, and health experts believe they can cause cancer. You've probably cooked up some yourself -- they're in the charred part of grilled meat.

But the stuff in storm water ponds isn't coming from barbecued chicken.

Storm water pond sediment

A lot of it is likely coming from coal tar. That's a byproduct of cooking coal to make coke, a fuel commonly used in steelmaking. Coal tar is used in products ranging from dandruff shampoo to blacktop sealant.

Millions of gallons of the sealant have been painted on parking lots, driveways and trails for decades. It's supposed to protect asphalt from sun, gasoline and oil.

The trouble is that the sealant doesn't stay put.

Judy Crane is the Minnesota Pollution Control Agency water quality scientist tracking down PAH. By kayak, she takes mud samples from the bottoms of storm water ponds to look for these and other chemicals.

Crane was in Woodbury on a recent rainy day, looking at a pond that drains into Carver Lake, a popular swimming spot. It's surrounded by homes with asphalt driveways.

A storm water pond in Woodbury

"There [are] different kinds of PAHs that we're looking at," she said. "We are looking at metals, and we are looking at some endocrine-disrupting compounds with octylphenols, nonylphenols and nonylphenol ethoxylates. There is like this whole big list."

PAH has been under increased scrutiny for most of the last decade, after a United States Geological Survey study found the contaminant in a Texas stream. They matched the chemical fingerprint to coal tar sealants.

So what should regulators do about the problem? There are three options.

The first is to do nothing.

Don Taylor is a Texas-based board member of the National Pavement Contractors Association and one of the nation's most outspoken defenders of coal tar. He is questioned whether it is a health hazard, and said it might be environmentally better to preserve existing asphalt.

"Side by side, all things being equal, it will wear longer on the pavement, in general," Taylor said. "It protects your asphalt better. It's a good product."

Scientist Judy Crane starts work

And Taylor said coal tar on is its way out anyway as sealcoaters are switching to cheaper, asphalt-based coatings.

Which brings us to strategy number two: getting rid of coal tar.

Opponents say it doesn't really work, and some stores, including Lowe's and Home Depot, have stopped selling it.

Austin, Texas, and Madison, Wisconsin, have banned it. And some Minnesota legislators say they will propose a state ban on using coal tar in asphalt sealants in the next legislative session.

MPCA storm water pond testing

State Representative Bev Scalze, a DFLer from Little Canada, sponsored the state funding for the study now underway by the MPCA. While Scalze supports a ban, she said prohibitions on specific products can be difficult to pass. But she hopes people will rethink their home maintenance habits, anyway.

"We've still got to get people to stop using coal tar on their driveways, and getting used to an asphalt driveway that's not solid black," Scalze said.

And finally, something has to be done with the PAH already out there.

PAH contamination means mud from storm water ponds is technically a hazardous waste. That means cities and counties will not be able to clean out ponds with a backhoe and use the mud somewhere else.

On the other hand, putting all the mud in a hazardous waste landfill could cost hundreds of millions of dollars. University of Minnesota scientists are studying ways to clean up PAH. A fungus that grows in wood compost may break down the contaminants.

In the meantime, the state will stop using coal tar on roads next summer. The tests being done this fall will tell if more action is needed to clean up Minnesota's storm water ponds.

Broadcast Dates

- Morning Edition, 11/02/2009, 7:20 a.m.

Appendix F: Jurisdictional Bans on Coal Tar Sealcoat Products in the U.S.

Austin, TX: Ordinance No. 20051117-070 adding a new Chapter 6-6 relating to coal tar pavement products, creating offenses, and providing penalties

Dane County, WI: Chapter 80 establishing regulations for lawn fertilizer and coal tar sealcoat products application and sale

Washington, DC: Comprehensive Stormwater Management Enhancement Amendment Act of 2008

ORDINANCE NO. 20051117-070

AN ORDINANCE AMENDING THE CITY CODE TO ADD A NEW CHAPTER 6-6 RELATING TO COAL TAR PAVEMENT PRODUCTS, CREATING OFFENSES, AND PROVIDING PENALTIES.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF AUSTIN:

PART 1. Title 6 of the City Code is amended to add a new Chapter 6-6 to read:

CHAPTER 6-6. COAL TAR PAVEMENT PRODUCTS.

§ 6-6-1 DEFINITIONS.

In this chapter:

(1) COAL TAR PAVEMENT PRODUCT means a material that contains coal tar and is for use on an asphalt or concrete surface, including a driveway or parking area.

(2) DIRECTOR means the director of the Watershed Protection and Development Review Department.

§ 6-6-2 USE OF COAL TAR PAVEMENT PRODUCTS PROHIBITED.

(A) Except as provided in Section 6-6-4 *(Exemptions)*, a person may not use a coal tar pavement product within the City's planning jurisdiction.

(B) A person who owns property on which a coal tar pavement product is used is presumed to have used a coal tar pavement product in violation of this section.

§ 6-6-3 SALE OF COAL TAR PAVEMENT PRODUCTS RESTRICTED.

Except as provided in Section 6-6-4 *(Exemptions)*, a person may not sell a coal tar pavement product within the City's planning jurisdiction, unless:

(1) the sale is to a person who intends to use the coal tar pavement product outside the City's planning jurisdiction; and

(2) the seller requires the purchaser to complete and sign a form provided by the director that includes:

(a) the name, address, and phone number of the purchaser;

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(b) the date of the purchase;

(c) the quantity of coal tar pavement product purchased;

(d) a statement that the coal tar pavement product will not be used within the City's planning jurisdiction; and

(e) an affirmation by the purchaser that the information on the form is correct; and

(3) the seller retains the completed form for a period of not less than three years and allows the director to inspect or copy the form upon request.

§ 6-6-4 EXEMPTIONS.

The director may exempt a person from a requirement of this chapter if the director determines that:

(1) the person is researching the effect of a coal tar pavement product on the environment or is developing an alternative technology, and the use of a coal tar pavement product is required for the research or development; or

(2) a viable alternative to a coal tar pavement product is not available for the intended use.

§ 6-6-5 OFFENSE; PENALTY.

(A) A person who violates this chapter commits a Class C misdemeanor punishable by:

(1) a fine not to exceed $500; or

(2) if the person acts with criminal negligence, a fine not to exceed $2,000.

(B) Each day that a violation occurs or continues is a separate offense.

(C) Proof of a higher degree of culpability than criminal negligence constitutes proof of criminal negligence.

PART 2. This ordinance takes effect on November 28, 2005.

PASSED AND APPROVED

November 17, 2005	§ § §	Will Wynn Mayor

APPROVED: David Allan Smith
City Attorney

ATTEST: Shirley A. Brown
City Clerk

ORDINANCE NO. 20051201-016

AN ORDINANCE AMENDING ORDINANCE NO. 20051117-070 TO CORRECT A TYPOGRAPHICAL ERROR RELATED TO THE EFFECTIVE DATE.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF AUSTIN:

PART 1. Part 2 of Ordinance No. 20051117-070 is amended to read:

This ordinance takes effect on January 1, 2006.

PART 2. This ordinance takes effect on December 12, 2005.

PASSED AND APPROVED

§
§
December 1, 2005 §

Will Wynn
Mayor

APPROVED:
David Allan Smith
City Attorney

ATTEST:
Shirley A. Brown
City Clerk

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CHAPTER 80
ESTABLISHING REGULATIONS FOR LAWN FERTILIZER AND COAL TAR SEALCOAT PRODUCTS APPLICATION AND SALE

80.01 AUTHORITY. This chapter is recommended by the Dane County Lakes and Watershed Commission and adopted by the Dane County Board of Supervisors under the authority of sec. 33.455, Wis. Stats.

80.02 PURPOSE AND INTENT. The Dane County Board of Supervisors finds that Dane County's lakes and streams are a natural asset which enhance the environmental, recreational, cultural and economic resources of the area and contribute to the general health and welfare of the public. The Board further finds that regulating the amount of nutrients and contaminants, including phosphorus contained in fertilizer and polycyclic aromatic hydrocarbons (PAHs) contained in coal tar sealcoat products, entering the lakes will improve and maintain lake water quality.
[History: am., OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07.]

80.03 APPLICABILITY. (1) This ordinance applies in all areas of Dane County.
(2) Cities and villages wholly or partially in Dane County may assume administration and regulation of lawn fertilizer and coal tar sealcoat products application and sale if they have adopted ordinances that include standards at least as restrictive as those described in ss. 80.05 – 80.09.
[History: (2) am., OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07.]

80.04 DEFINITIONS. (1) *Agricultural use* has the meaning set forth in sec. 10.01(2a).
(2) *Coal tar* is a byproduct of the process used to refine coal. *Coal tar* contains high levels of polycyclic aromatic hydrocarbons (PAHs).
(3) *Fertilizer* has the meaning set forth in sec. 94.64(1)(e), Wis. Stats.
(4) *Lawn fertilizer* means any fertilizer, whether distributed by property owner, renter or commercial entity, distributed for nonagricultural use, such as for lawns, golf courses, parks and cemeteries. *Lawn fertilizer* does not include fertilizer products intended primarily for garden and indoor plant application.
(5) *Polycyclic aromatic hydrocarbons (PAHs)* are a group of organic chemicals that are present in coal tar and are an environmental concern because they are toxic to aquatic life.
(6) *Sealcoat* is a black liquid that is sprayed or painted on asphalt pavement in an effort to protect and beautify the asphalt. Most sealcoat products are coal tar or asphalt based.
[History: (2) and (3) renum., respectively, as (3) and (4) and a new (2), (5) and (6) cr., OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07.]

80.05 REGULATION OF THE USE AND APPLICATION OF LAWN FERTILIZER. (1) Effective January 1, 2005, no person shall apply any lawn fertilizer within Dane County that is labeled as containing more than 0% phosphorus or other compound containing phosphorus, such as phosphate, except as provided in section 80.06.
(2) No lawn fertilizer shall be applied when the ground is frozen.
(3) No person shall apply fertilizer to any impervious surface including parking lots, roadways, and sidewalks. If such application occurs, the fertilizer must be immediately contained and either legally applied to turf or placed in an appropriate container.

80.06 EXEMPTIONS. The prohibition against the use of fertilizer under section 80.05 shall not apply to:
(1) Newly established turf or lawn areas during their first growing season.

(2) Turf or lawn areas that soil tests, performed within the past three years by a state-certified soil testing laboratory, confirm are below phosphorus levels established by the University of Wisconsin Extension Service. The lawn fertilizer application shall not contain an amount of phosphorus exceeding the amount and rate of application recommended in the soil test evaluation.
(3) Agricultural uses, vegetable and flower gardens, or application to trees or shrubs.
(4) Yard waste compost, biosolids or other similar materials that are primarily organic in nature and are applied to improve the physical condition of the soil.

80.07 SALE OF FERTILIZER CONTAINING PHOSPHORUS. (1) Effective January 1, 2005, no person shall sell or offer for sale any lawn fertilizer within Dane County that is labeled as containing more than 0% phosphorus, or other compound containing phosphorus, such as phosphate, except such fertilizer may be sold for use as provided in section 80.06.
(2) Effective January 1, 2005, no person shall display lawn fertilizer containing phosphorus. Signs may be posted advising customers that lawn fertilizer containing phosphorus is available upon request for uses permitted by s. 80.06.
(3) Effective May 1, 2004, a sign containing the regulations set forth in this ordinance and the effects of phosphorus on Dane County's waters must be prominently displayed where lawn fertilizers are sold.

80.08 REGULATION OF THE APPLICATION AND SALE OF SEALCOAT PRODUCTS CONTAINING COAL TAR. (1) No person shall apply any sealcoat product within Dane County that is labeled as containing coal tar.
(2) No person shall sell, offer to sell, or display for sale any sealcoat product within Dane County that is labeled as containing coal tar.
(3) Any person who sells pavement sealcoat products shall prominently display, in the area where such pavement sealcoat products are sold, a notice that contains the following language: "The application of coal tar sealcoat products on driveways, parking lots and all other paved surfaces in Dane County is prohibited by section 80.08 of the Dane County Code of Ordinances. Coal tar is a significant source of polycyclic aromatic hydrocarbons (PAHs), a group of organic chemicals that can be carried by stormwater and other runoff into Dane County's lakes and streams. PAHs are an environmental concern because they are toxic to aquatic life."
[**History:** 80.08 renum. as 80.10 and a new 80.08 cr., OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07; (3) will be repealed eff. 04/01/09 unless re-enacted by the Co. Bd., OA 4, 2007-08, pub. 06/01/07.]

80.09 EXEMPTIONS. (1) The sale of a sealcoat product containing coal tar to a person who intends to apply the product on a surface that is not located within Dane County is permitted under the following conditions:
(a) The seller requires the purchaser to complete and sign a form, to be provided by the Land and Water Resources Department, that includes the purchaser's name, address, phone number, date of purchase, quantity purchased and a statement that the coal tar sealcoat product will not be applied on a surface that is located within Dane County.
(b) The seller retains the completed form for a period of not less than three (3) years from the date of sale and allows the inspection and copying of the form by Dane County staff upon request.
(2) The Director of the Land and Water Resources Department may exempt a person from the requirements of section 80.08 if the person is conducting *bona fide* research concerning the effects of a coal tar sealant product on the environment and the use of the coal tar product is required for said research.
[**History:** 80.09 renum. as 80.11 and a new 80.09 cr., OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07.]

80.10 ENFORCEMENT. Violations of this ordinance will be enforced by the Environmental Health Section of the Public Health Division of the Department of Human Services, or any successor organization.
[**History:** 80.10 renum. as 80.12 and 80.08 renum. as 80.10 and, as renum., am., OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07.]

80.11 PENALTY. (1) Any person who violates section 80.05 in the application of fertilizer at his or her residence shall be subject to a forfeiture of $25 per violation.
(2) Any person who violates section 80.08(1) by applying a coal tar sealant product at his or her residence shall be subject to a forfeiture of $25 per violation.

(3) Any commercial fertilizer applicator, residential or commercial developer, industrial or commercial owner, or other person who violates section 80.05, and any person who violates section 80.07, shall be subject to a forfeiture of $50 for the first violation within a twelve month period, $150 for the second violation within a twelve month period, and $300 for the third and each subsequent violation within a twelve month period.

(4) Any commercial sealcoat product applicator, residential or commercial developer, industrial or commercial owner, or any other person, other than a person identified under sub. (2) above, who violates section 80.08, shall be subject to a forfeiture of $50 for the first violation within a twelve month period, $150 for the second violation within a twelve month period, and $300 for the third and each subsequent violation within a twelve month period.

(5) Any person who applies, sells, offers to sell or displays for sale any sealcoat product within Dane County that is labeled as containing coal tar is presumed to have applied, sold, offered to sell or displayed the product in violation of this section.

[History: 80.09 renum. as 80.11 and, as renum., am., OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07.]

80.12 SEVERABILITY CLAUSE. If any section, provision or portion of this ordinance is ruled invalid by a court, the remainder of the ordinance shall not for that reason be rendered ineffective or invalid.

[History: 80.10 renum. as 80.12, OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07.]

[80.13 – 80.99 reserved.]

[History: Ch. 80 (sec. 80.01 through 80.10) cr., Sub. 1 to OA 33, 2003-04, pub. 04/30/04; Chapter Title am., OA 34, 2006-07, pub. 04/19/07, eff. 07/01/07.]

END OF CHAPTER

AN ACT

____

IN THE COUNCIL OF THE DISTRICT OF COLUMBIA

____

Codification District of Columbia Official Code

2001 Edition

2009 Summer Supp.

West Group Publisher

To amend the District Department of the Environment Establishment Act of 2005 to establish stormwater management programs to reduce the amount of stormwater pollutants that are discharged into District rivers and streams and to collect scientific data on the effects of low impact development on reducing stormwater runoff and the potential for aggressive use of low impact development technologies to reduce the cost and size of any large-scale civil engineering solutions to reducing stormwater pollution of the area's waterways, to expand the authority and responsibilities of the Director of the District Department of the Environment relating to Stormwater Permit compliance and activities, to elevate the Stormwater Permit Compliance Enterprise Fund to the program level and to include fund activities in the Mayor's annual budget, to establish a Stormwater User Fee Discount Program to offer incentives to encourage the installation of innovative stormwater management controls, to provide for the reduction of impervious surfaces in public space, to institutionalize progressive stormwater management practices for District agencies, to expand the membership of the Stormwater Advisory Panel to improve stormwater management coordination between District agencies, and to create limitations on the usage and sale of coal tar pavement product; to amend the Water and Sewer Authority Establishment and Department of Public Works Reorganization Act of 1996 to modify the stormwater user fee structure using a city-wide impervious area methodology, and thereby establish a more accurate and equitable assessment of stormwater runoff generated from properties, and the costs associated with managing that runoff, to provide adequate and stable funding for MS4 permit implementation, to permit owners of properties charged stormwater user fees to contest stormwater user fee bills,, and to require the Mayor to offer financial assistance programs to mitigate the impact of increases in stormwater user fees on low-income residents of the District.

BE IT ENACTED BY THE COUNCIL OF THE DISTRICT OF COLUMBIA, That this act may be cited as the "Comprehensive Stormwater Management Enhancement Amendment Act of 2008".

Sec. 2. The District Department of the Environment Establishment Act of 2005, effective February 15, 2006 (D.C. Law 16-51; D.C. Official Code § 8-151.01 *et seq.*), is amended as follows:

(a) Section 101 (D.C. Official Code § 8-151.01) is amended to read as follows: **Amend § 8-151.01**

"Sec. 101. Definitions.

"For the purposes of this act, the term:

"(1) "CapStat" means an accountability program that examines performance data to improve government services to make the District of Columbia government run more efficiently, using a methodical process for focusing the attention of government representatives on improving performance in priority issues that cross agency boundaries.

"(2) "DDOE" means the District Department of the Environment.

"(3) "Director" means the Director of the District Department of the Environment.

"(4) "Environment" means the physical conditions and natural resources of the District, including the land, air, water, minerals, flora, and fauna in the District, and the waters adjacent to the District.

"(5) "Environmental Management System" or "EMS" means an interagency data system to inventory, track, and report on progress towards performance standards and activities. The term "EMS" includes an adaptive management approach that incorporates planning, implementing, monitoring, evaluating, and adjusting the interagency data system.

"(6) "Impervious area stormwater user fee" or "stormwater user fee" means a fee that attributes the cost of conveying stormwater run-off via a sewer from a given property, to the quantity of stormwater run-off generated from that same property, by use of impervious surface as a surrogate metric.

"(7) "Impervious surface" means a surface area that either prevents or retards the entry of water into the ground as occurring under natural conditions, or that causes water to run off the surface in greater quantities or at an increased rate of flow, relative to the flow present under natural conditions.

"(8) "Low Impact Development" or "LID" means stormwater management practices that mimic site hydrology under natural conditions, by using design techniques in construction and development that store, infiltrate, evaporate, detain, or reuse and recycle runoff.

"(9) "MS4" means the Municipal Separate Storm Sewer System serving approximately two-thirds of the District, and comprised of 2 independent piping systems: one system for sewage from homes and businesses, and one system for stormwater.

"(10) "Natural conditions" means the state of the environment prior to anthropogenic intervention.

"(11) "Primacy" means the grant or delegation of authority under certain federal environmental laws that allows states and the District to assume primary authority to enforce and implement the environmental laws and promulgate regulations pursuant to those laws.

"(12) "SDWA" means the Safe Drinking Water Act, approved December 16, 1974 (88 Stat. 1660; 42 U.S.C. § 300f *et seq.*).

"(13) "Sewer" shall have the same meaning as provided in section 201(9) of the Water and Sewer Authority Establishment and Department of Public Work Reorganization Act of 1996, effective April 18, 1996 (D.C. Law 11-111; D.C. Official Code § 34-2202.01(9))."

"(14) "Stormwater best management practice" means a structure used to reduce the volume or the pollutant content of a stormwater discharge.

"(15) "Stormwater Permit" or "MS4 Permit" means NPDES No. DC0000221, issued April 20, 2000 to the District of Columbia by the Environmental Protection Agency.".

(b) A new Title I-A is added to read as follows:

"TITLE I-A. STORMWATER MANAGEMENT.

"Sec. 151. Stormwater Administration.

"(a) There is established within the District Department of the Environment a Stormwater Administration ("Administration"), pursuant to section 103(b)(2). The Administration shall be responsible for monitoring and coordinating the activities of all District agencies, including the activities of the District of Columbia Water and Sewer Authority ("DC WASA"), which are required to maintain compliance with the Stormwater Permit. The Director shall designate a Stormwater Administrator to manage the Administration.

"(b) The expenses of the Administration shall be disbursed from the Stormwater Permit Compliance Enterprise Fund established pursuant to section 152.

"(c) The District Department of Transportation, the Department of Public Works, the Office of Planning, the Office of Public Education Facilities Modernization, the Office of Property Management, the Department of Parks and Recreation, and DC WASA, and any other District agency identified by the Director ("Stormwater Agencies"), shall comply with all requests made by the Director relating to stormwater related requests, compliance measures, and activities, including the adoption of specific standards, and the submission of information, plans, proposed budgets, or supplemental budgets related to stormwater activities. In coordination with the submission of the report required by subsection (f) of this section, the Stormwater Agencies shall submit annual reports of steps implemented to fulfill or exceed their MS4 Permit obligations, as defined by the Director.

"(d) At least once each fiscal year in a CapStat or comparable session, the Mayor shall review the compliance of the Stormwater Agencies with the requests made by the Director relating to MS4 Permit compliance and activities.

"(e) All budgets submitted by the Mayor to the Council shall include a written determination by the Director of whether the budget adequately funds MS4 Permit compliance and activities. The Director shall inform the Council of any deficiency, and indicate the revisions that shall be made to correct the deficiency.

"(f) The Director shall provide to the Mayor, the Council, and the public, the annual report submitted to the Environmental Protection Agency ("EPA") under the terms of the Stormwater Permit.

"(g) Within one year of the effective date of this section, the Director shall institute an Environmental Management System to inventory, track, and report on pollution prevention and stormwater management activities, and to hold the Stormwater Agencies accountable for progress toward meeting the performance standards and obligations required to meet the stormwater management plan of the Stormwater Permit.

"Sec. 152. Stormwater Permit Compliance Enterprise Fund.

"(a) There is established within the District Department of the Environment a Stormwater Permit Compliance Enterprise Fund ("Enterprise Fund"), pursuant to section 103(b)(2). The Director shall allocate the Fund resources to carry out the MS4 Permit activities that have the greatest impact on reducing stormwater pollution.

"(b) Beginning in fiscal year 2010 and each year thereafter, the Mayor shall propose the Fund with an agency level budget. The Mayor shall submit to the Council, as part of the annual budget, proposed budgets that include expenditures of the Enterprise Fund for stormwater programs, including intra-District funds sufficient to fulfill the MS4 Permit obligations of the Stormwater Agencies. The proposed budgets may include funding for large-scale, multiyear projects. The Mayor shall establish benchmark and performance-measure outcomes that connect stormwater programs with funding levels.

"(c) All revenues, proceeds, and moneys collected from the stormwater user fee or from grants made for stormwater activities that are collected or received, shall be credited to the Enterprise Fund and shall not, at any time, be transferred to, lapse into, or be commingled with the General Fund of the District of Columbia, the Water and Sewer Authority General Fund, the Cash Management Pool, or any other funds or accounts of the District of Columbia.

"(d) Monies from the Enterprise Fund shall only be used to fund the costs of complying with the MS4 Permit, including grants for stormwater activities, all administrative, operating, and capital costs of DC WASA and the agencies identified by the Director as having specific responsibilities under the, MS4 Permit and the Stormwater Administration established pursuant to section 151. The Enterprise Fund shall also be used for DC WASA's costs of billing and collecting the stormwater user fee, as authorized by District of Columbia Public Works Act of 1954, approved May 18, 1954 (68 Stat. 104; D.C. Official Code § 34-2101.01 *et seq.*).

"(e) Monies shall not be disbursed from the Enterprise Fund for costs associated with:

"(1) Stormwater management activities carried out prior to April 20, 2000, except to the extent those costs increased to comply with the terms of the Stormwater Permit; or

"(2) Stormwater management activities otherwise required by law or regulation, unless specifically permitted by the Director.

"(f) Within 90 days of the effective date of this section, the Office of the Chief Financial Officer shall convene quarterly meetings to coordinate with the fiscal officers of the Stormwater Agencies to ensure that each agency can access the Enterprise Fund to implement its activities in a timely manner.

"Sec. 153. Stormwater User Fee Discount Program.

"(a) Within one year of the enactment of an impervious area stormwater user fee by DC

WASA, the Mayor shall establish a Stormwater User Fee Discount Program to be coordinated between DC WASA and the Administration.

"(b) The program shall allow property owners who implement measures to manage stormwater runoff from their properties to receive a discount on the stormwater user fee assessed to them under section 216 of the Water and Sewer Authority Establishment and Department of Public Works Reorganization Act of 1996, effective April 18, 1996 (D.C. Law 11-111; D.C. Official Code § 34-2202.16).

"(c) Stormwater user fee discounts approved by the Mayor shall be retroactive to no earlier than the date of the implementation of the impervious area stormwater fee. A property owner may not qualify for a stormwater user fee discount until the stormwater management measures for which they seek a discount are demonstrated to be fully functional.

"(d) Any discount earned under this section will be revocable upon a finding by the Mayor of non-performance. Upon a finding of non-performance, the Mayor may require reimbursement of any portion of fees discounted to date.

"(e) Findings of non-performance by the Mayor may be appealed by an applicant pursuant to rules established by the Mayor.

"(f) Failure to reimburse may result in a lien being placed upon the property without further notice to the owner. The Mayor may enforce the lien in the same manner as in District of Columbia Public Works Act of 1954, approved May 18, 1954 (68 Stat. 102; D.C. Official Code § 34-2407.02).

"Sec. 154. Stormwater management and Low Impact Development grants.

"(a) The Mayor, in coordination with DC WASA, shall establish a grant program to provide Enterprise Funds for grants and direct services to property owners in the District to employ LID or stormwater best management practices.

"(b) Funding for such grants will be contingent on maintaining adequate Enterprise Funds to address District obligations pursuant to the MS4 Permit.

"(c) Within one year of the effective date of this section, the Director of the Department of Transportation ("DDOT") shall submit to the Director an action plan recommending policies and measures to reduce impervious surfaces and promote LID projects in the public space. The action plan shall incorporate:

"(1) New DDOT policies to reduce impervious surface and employ other LID measures in right-of-way construction projects and retrofit projects;

"(2) A revised DDOT public space permitting process and the development of a mechanism to minimize stormwater runoff from the public right-of-way;

"(3) Requirements and incentives for private developers to reduce impervious surface and employ LID measures when their projects extend into the public right-of-way;

"(4) Policies, including fees, for the use of public space to manage stormwater runoff from private property;

"(5) Policies to address ongoing maintenance of LID or stormwater best management practices installed in public right-of-way areas adjacent to private property;

"(6) Strategies to remove impediments to LID projects on residential properties relating to public space; and

"(7) Costs for each recommendation and a recommended timeline for funding in the Mayor's proposed budget. The Mayor shall incorporate these recommendations in the next and subsequent proposed annual budgets.

"(d)(1) Within one year of the effective date of this section, the Director, together with the Stormwater Agencies, shall prepare a study recommending policies and measures developed to implement LID and stormwater best management practices on District properties. The Mayor shall incorporate these recommendations in the next and subsequent proposed annual budgets.

"(2) For each LID or stormwater best management practice installed, the Mayor shall require a maintenance agreement by District agencies to provide for their ongoing operation and maintenance to ensure installed practices continue to function as designed and installed to provide stormwater pollution reductions.

"(e) The Director shall include among DDOE's public educational efforts a campaign to inform the public on the benefits of preventing pollution from stormwater runoff, and to provide recommendations on how the general public can help keep the District's waterways free of pollution. The Director shall also initiate outreach actions with upstream jurisdictions to encourage their implementation of similar stormwater reduction activities.

"(f) The Director shall work with DC WASA to collect and evaluate scientific data on the effects of low impact development on reducing stormwater runoff to develop a plan for aggressive use of low impact development technologies to reduce the cost and size of any large-scale civil engineering solutions to reducing stormwater pollution of the area's waterways. The Director shall inform the Stormwater Advisory Panel, and representatives of upstream jurisdictions, the Washington Metropolitan Area Transit Authority, and the federal government of the scientific data and analyses drawn from the data.

"Sec. 155. Stormwater Advisory Panel.

"(a) There is established within the District Department of the Environment a Stormwater Advisory Panel ("Panel"), pursuant to section 103(b)(2). The Panel shall coordinate the responsibilities of the agencies and DC WASA, and shall prepare comprehensive recommendations to the Council that identify the best means by which the District can meet or exceed all present and future federal regulatory and permit requirements, pertaining to the discharge of stormwater into receiving waters.

"(b) The Panel shall be comprised of the executive officers with responsibilities pursuant to the MS4 Permit, with oversight responsibility for the administrative and financial aspects of stormwater management, or that engage in activities that impact the District's stormwater discharge:

"(1) The members of the Panel shall be:

"(A) The City Administrator;

"(B) The Chief Financial Officer;

"(C) The Director, who will serve as the Panel's Chair;

"(D) The Stormwater Administrator;
"(E) The Director of the Department of Transportation;
"(F) The Director of the Department of Public Works;
"(G) The Director of the Office of Planning;
"(H) The Director of the Office of Public Education Facilities Modernization;
"(I) The Director of the Office of Property Management;
"(J) The Director of the Department of Parks and Recreation; and
"(K) The General Manager of DC WASA.

"(2) The Director may designate additional members from other agencies whose activities impact the District's stormwater runoff.

"(3) The Director shall engage and encourage participation from representatives of the Washington Metropolitan Area Transit Authority and the federal government, including the U.S. General Services Administration and the National Parks Service.

"(c) The Panel shall hold its first meeting within 90 days of the effective date of this section. The Panel shall hold at least one public hearing to receive testimony from citizens with respect to the issues stated in subsection (e)(1) and (2) of this section.

"(d) The Panel shall meet at least 2 times each year.

"(e) The Panel shall provide its recommendations in the annual report required to be submitted to EPA Region III under the MS4 Permit. The report shall make specific findings on:

"(1) Whether the existing allocation of stormwater management responsibilities among District agencies are capable of fulfilling or exceeding present and future regulatory requirements for stormwater discharge, and if not, what changes need to be made or new government entities created;

"(2) Comprehensive recommendations, specific standards adopted, and steps implemented by the respective agency to fulfill or exceed its obligation to meet its share of federal regulatory and MS4 Permit requirements pertaining to the discharge of stormwater into receiving waters; and

"(3) Whether the existing stormwater user fee structure and rates are equitable and sufficient for the District to fulfill or exceed its present and future regulatory requirements for stormwater discharge, and, if not, what changes in fee structure and rate would be required to fulfill these responsibilities.

"(f) Within one year of the effective date of this section, the Panel shall provide to the Council and the Mayor a study of the needs for achieving water quality compliance from the District's stormwater runoff.

"(g) Panel members shall ensure that their agencies participate in the Environmental Management System to track compliance with the District's MS4 Permit obligations and other stormwater management responsibilities required to reduce pollution to the District's waters.

"(h) Within 120 days after the effective date of this act, the Panel shall establish a Technical Working Group ("TWG") of agency technical staff.

"(1) The TWG shall consist of the following 14 members:

"(A) Each Panel member shall appoint one member of the TWG.

"(B) The Mayor, the Chairman of the Council of the District of Columbia, and the Chairman of the Council committee with oversight over the District Department of the Environment shall each appoint one member; provided, that the appointees shall be non-agency stakeholders who are geographically diverse, and shall have expertise in stormwater management, land development, hydrology, natural resources conservation, environmental protection, environmental law, or other similar stormwater management expertise.

"(2) TWG members shall serve a 2-year term, and without compensation.

"(3) The Chairperson of the TWG shall be the Stormwater Administrator.

"(4) The TWG shall attend monthly meetings with the Stormwater Administrator and coordinate tracking and reporting of stormwater management activities of their agencies' efforts. The TWG shall also:

"(A) Advise the Panel on technical matters and respective agency MS4 Permit compliance requirements;

"(B) Make recommendations to the Panel regarding existing District agency rules, regulations, and policies that might create barriers to the implementation of LID or stormwater best management practices in the District; and

"(C) Suggest programmatic incentives for best management practices which were successfully implemented in other jurisdictions to promote the implementation of these stormwater management practices on new and existing properties in the District.

"(5) DDOE shall provide staff assistance to the TWG.".

(c) A new Title I-B is added to read as follows:

"TITLE I-B. PRODUCT LIMITATION OF STORMWATER MANAGEMENT.

"Sec. 181. Coal tar limitations.

"(a) For the purposes of this section, the term "coal tar pavement product" means a material that contains coal tar and is for use on an asphalt or concrete surface, including a driveway or parking lot.

"(b) No person shall sell, offer for sale, use, or permit to be used, on property he or she owns, a coal tar pavement product.

"(c)(1) Any person who violates this section shall be liable to the District for a civil penalty in an amount not to exceed $ 2,500 for each violation.

"(2) For any violation, each day of the violation shall constitute a separate offense and the penalties prescribed shall apply separately to each offense.

"(3) Adjudication of any infraction of this section shall be pursuant to the Department of Consumer and Regulatory Affairs Civil Infractions Act of 1985, effective October 5, 1985 (D.C. Law 6-42; D.C. Official Code § 2-1801.01 *et seq.*).

"(d) This section shall apply as of July 1, 2009.".

Sec. 3. The Water and Sewer Authority Establishment and Department of Public Works Reorganization Act of 1996, effective April 18, 1996 (D.C. Law 11-111; D.C. Official Code § 34-2201.01 *et seq.*), is amended as follows:

(a) Section 201(9A) and (9B) (D.C. Official Code § 34-2202.01(9A) and (9B)) are repealed. **Amend § 34-2202.01**

(b) Sections 206a, 206b, and 206c (D.C. Official Code §§ 34-2202.06a, 34-2202.06b, and 34-2202.06c) are repealed. **Repeal §§ 34-2202.06a, 34-2202.06b, 34-2202.06c**

(c) Section 216 (D.C. Official Code § 34-2202.16).is amended as follows: **Amend § 34-2202.16**

(1) Subsections (d-1) through (d-3) are amended to read as follows:

"(d-1) The Authority shall collect a stormwater user fee established by the Director of the District Department of the Environment ("Director"), which charge the Director shall establish by rule and may from time to time amend.

"(d-2) The fee shall be collected from each property in the District of Columbia, and shall be based on an impervious area assessment of the property.

"(d-3) The Mayor shall coordinate the development and implementation of the MS4 stormwater user fee with DC WASA's impervious area surface charge, to ensure that both fee systems employ consistent methodologies.".

(2) New subsections (d-4), (d-5), (d-6), and (d-7) are added to read as follows:

"(d-4) The Mayor shall offer financial assistance programs to mitigate the impact of any increases in stormwater user fees on low-income residents of the District, and shall evaluate the applicability of similar existing District low-income assistance programs to the stormwater user fee.

"(d-5) A landlord shall not pass a stormwater user fee charge to a tenant which is more than the stormwater user fee charge prescribed by the Director

"(d-6) The stormwater user fee shall be the obligation of the property owner. Failure to pay the stormwater user fee shall result in a lien being placed upon the property without further notice to the owner. The Mayor may enforce the lien in the same manner as in section 104 of the District of Columbia Public Works Acts of 1954, approved May 18, 1954 (68 Stat.102; D.C. Official Code § 34-2407).

"(d-7) Any owner or occupant of a property that is charged a stormwater user fee may contest a stormwater user fee bill rendered for managing stormwater runoff, according to the same procedures provided to owners or occupants of properties that receive water and sewer services, under section 1805 of the District of Columbia Public Works Act of 1954, effective June 13, 1990 (D.C. Law 8-136; D.C. Official Code § 34-2305).".

Sec. 4. Rules.

Within 180 days of the effective date of this act, the Mayor, pursuant to Title I of the District of Columbia Administrative Procedure Act, approved October 21, 1968 (82 Stat. 1204; D.C. Official Code § 2-501 *et seq.*), shall issue rules to implement the provisions of this act. The proposed rules shall be submitted to the Council for a 45-day period of review, excluding

Saturdays, Sundays, legal holidays, and days of Council recess. If the Council does not approve or disapprove the proposed rules, in whole or in part, by resolution within this 45-day review period, the proposed rules shall be deemed approved.

Sec. 5. Fiscal impact statement.

The Council adopts the fiscal impact statement of the Chief Financial Officer, dated December 15, 2008, as the fiscal impact statement required by section 602(c)(3) of the District of Columbia Home Rule Act, approved December 24, 1973 (87 Stat. 813; D.C. Official Code § 1-206.02(c)(3)).

Sec. 6. Effective date.

This act shall take effect following approval by the Mayor (or in the event of veto by the Mayor, action by the Council to override the veto), a 30-day period of Congressional review as provided in section 602(c)(1) of the District of Columbia Home Rule Act, approved December 24, 1973 (87 Stat. 813; D.C. Official Code § 1-206.02(c)(1)), and publication in the District of Columbia Register.

____
Chairman
Council of the District of Columbia

____
Mayor
District of Columbia

Appendix G: Michigan House Bill No. 5706 to Ban the Sale and Use of Coal Tar-based Sealcoat Products with Certain Exceptions

From: http://www.legislature.mi.gov/documents/2009-2010/billintroduced/House/htm/2009-HIB-5706.htm

HOUSE BILL No. 5706

December 16, 2009, Introduced by Reps. Warren, Liss, Tlaib, Donigan and Scripps and referred to the Committee on Great Lakes and Environment.

A bill to amend 1994 PA 451, entitled

"Natural resources and environmental protection act,"

(MCL 324.101 to 324.90106) by adding part 149.

THE PEOPLE OF THE STATE OF MICHIGAN ENACT:

PART 149. COAL TAR PRODUCTS

SEC. 14901. AS USED IN THIS PART:

(A) "COAL TAR PRODUCT" MEANS A PRODUCT CONTAINING COAL TAR.

(B) "DEPARTMENT" MEANS THE DEPARTMENT OF ENVIRONMENTAL QUALITY.

(C) "DIRECTOR" MEANS THE DIRECTOR OF THE DEPARTMENT OR HIS OR HER DESIGNEE.

(D) "PAVEMENT" MEANS AN ASPHALT, CONCRETE, OR OTHER PAVEMENT SURFACE.

SEC. 14903. (1) EXCEPT AS PROVIDED IN SECTION 14907, A PERSON SHALL NOT APPLY A COAL TAR PRODUCT ON ASPHALT, CONCRETE, OR OTHER PAVEMENT.

(2) A PERSON WHO OWNS PROPERTY ON WHICH A COAL TAR PRODUCT IS APPLIED IN VIOLATION OF SUBSECTION (1) IS REBUTTABLY PRESUMED TO HAVE APPLIED THE COAL TAR PRODUCT.

SEC. 14905. (1) EXCEPT AS PROVIDED IN SECTION 14907, A PERSON SHALL NOT SELL A COAL TAR PRODUCT THAT IS FORMULATED OR MARKETED FOR APPLICATION ON ASPHALT, CONCRETE, OR OTHER PAVEMENT, UNLESS THE PURCHASER COMPLETES AND SIGNS A FORM THAT INCLUDES ALL OF THE FOLLOWING:

(A) THE NAME, ADDRESS, AND TELEPHONE NUMBER OF THE PURCHASER.

(B) THE DATE OF THE PURCHASE.

(C) THE QUANTITY OF COAL TAR PRODUCT PURCHASED.

(D) A STATEMENT THAT THE COAL TAR PRODUCT WILL NOT BE USED WITHIN THIS STATE.

(E) AN AFFIRMATION BY THE PURCHASER THAT THE INFORMATION ON THE FORM IS CORRECT.

(2) A PERSON WHO SELLS A COAL TAR PRODUCT THAT IS FORMULATED OR MARKETED FOR APPLICATION ON PAVEMENT SHALL RETAIN THE COMPLETED FORM REQUIRED UNDER SUBSECTION (1) FOR NOT LESS THAN 3 YEARS AND ALLOW THE DEPARTMENT TO INSPECT OR COPY THE FORM UPON REQUEST.

(3) THE DEPARTMENT SHALL POST ON ITS WEBSITE A FORM SUITABLE FOR COMPLIANCE WITH SUBSECTION (1).

(4) A PERSON SHALL NOT SIGN A FORM REQUIRED UNDER SUBSECTION (1) IF THE FORM CONTAINS FALSE INFORMATION.

SEC. 14907. THE DIRECTOR MAY EXEMPT A PERSON FROM A REQUIREMENT OF THIS PART IF THE DIRECTOR DETERMINES THAT 1 OR MORE OF THE FOLLOWING APPLY:

(A) THE PERSON IS RESEARCHING THE EFFECT OF A COAL TAR PRODUCT ON THE ENVIRONMENT OR IS DEVELOPING AN ALTERNATIVE TECHNOLOGY, AND THE USE OF A COAL TAR PRODUCT IS REQUIRED FOR THE RESEARCH OR DEVELOPMENT.

(B) A SUITABLE ALTERNATIVE TO THE COAL TAR PRODUCT IS NOT

AVAILABLE FOR THE INTENDED USE.

SEC. 14909. A PERSON WHO VIOLATES THIS PART IS RESPONSIBLE FOR A STATE CIVIL INFRACTION AND MAY BE ORDERED TO PAY A CIVIL FINE OF NOT MORE THAN $1,000.00.-

Appendix H: Minnesota House File No. 1231, Including a Ban on the Usage of Coal Tar Sealcoat Products by State Agencies in Minnesota

Information for House File (HF) No. 1231 Passed by the Minnesota Legislature on May 18, 2009 and Approved by Governor Tim Pawlenty on May 22, 2009

86th Legislative Session (2009 – 2010)

Short Description: Dedicated funding provided for natural resource and cultural heritage, and money appropriated.

Note: A summary of the actions taken by the Minnesota House and Senate that led to the passage of HF 1231 is available on the Minnesota Legislative web site at: https://www.revisor.leg.state.mn.us/revisor/pages/search_status/status_detail.php?b=House&f=HF1231&ssn=0&y=2009.

The content of the final bill passed by the Minnesota Legislature on May 18, 2009 is available at: https://www.revisor.leg.state.mn.us/bin/bldbill.php?bill=ccrhf1231.html&session=ls86. The sections pertaining to the coal tar component of this bill are pasted in below.

H.F. No. 1231, Conference Committee Report - 86th Legislative Session (2009-2010) Posted on May 18, 2009

CONFERENCE COMMITTEE REPORT ON H. F. No. 1231

A bill for an act

relating to state government; appropriating money from constitutionally dedicated funds and providing for policy and governance of outdoor heritage, clean water, parks and trails, and arts and cultural heritage purposes; establishing and modifying grants and funding programs; providing for advisory groups; providing appointments; requiring reports; requiring rulemaking; amending Minnesota Statutes 2008, sections 3.303, by adding a subdivision; 3.971, by adding a subdivision; 17.117, subdivision 11a; 18G.11, by adding a subdivision; 84.02, by adding subdivisions; 85.53; 97A.056, subdivisions 2, 3, 6, 7, by adding subdivisions; 103F.515, subdivisions 2, 4; 114D.50; 116G.15; 116P.05, subdivision 2; 129D.17; 477A.12, subdivision 2; proposing coding for new law in Minnesota Statutes, chapters 3; 84; 84C; 85; 116; 129D; 138; 477A.

May 18, 2009

The Honorable Margaret Anderson Kelliher
Speaker of the House of Representatives

The Honorable James P. Metzen
President of the Senate

We, the undersigned conferees for H. F. No. 1231 report that we have agreed upon the items in dispute and recommend as follows:

That the Senate recede from its amendment and that H. F. No. 1231 be further amended as follows:

Delete everything after the enacting clause and insert:

Sec. 4. **POLLUTION CONTROL AGENCY $ 24,076,000 $ 27,285,000**

(g) $155,000 the first year is to provide notification of the potential for coal tar contamination, establish a storm water pond inventory schedule, and develop best management practices for treating and cleaning up contaminated sediments as required in this article. $345,000 the second year is to develop a model ordinance for the restricted use of undiluted coal tar sealants and to provide grants to local units of government for up to 50 percent of the costs to implement best management practices to treat or clean up contaminated sediments in storm water ponds and other waters as defined under this article. Local governments must have adopted an ordinance for the restricted use of undiluted coal tar sealants in order to be eligible for a grant, unless a statewide restriction has been implemented. A grant awarded under this paragraph must not exceed $100,000.

Sec. 26. **[116.201] COAL TAR.**

A state agency may not purchase undiluted coal tar sealant. For the purposes of this section, "undiluted coal tar sealant" means a sealant material containing coal tar that has not been mixed with asphalt and is for use on asphalt surfaces, including driveways and parking lots.

EFFECTIVE DATE. This section is effective July 1, 2010.

Sec. 28. ***PREVENTION OF WATER POLLUTION FROM POLYCYCLIC AROMATIC HYDROCARBONS.***

(a) By January 15, 2010, the commissioner of the Pollution Control Agency shall notify state agencies and local units of government of the potential for contamination of constructed storm water ponds and wetlands or natural ponds used for the collection of storm water via constructed conveyances with polycyclic aromatic hydrocarbons from the use of coal tar sealant products. For the purpose of this section, a storm water pond is a treatment pond constructed and operated for water quality treatment, storm water detention, and flood control. Storm water ponds do not include areas of temporary ponding, such as ponds that exist only during a construction project or short-term accumulations of water in road ditches.

(b) By January 15, 2010, the commissioner of the Pollution Control Agency shall establish a schedule and information requirements for state agencies and local units of government regulated under a national pollutant discharge elimination system or state disposal system permit for municipal separate storm sewer systems to report to the commissioner of the Pollution Control Agency on all storm water ponds and other waters defined in paragraph (a) located within their jurisdiction.

(c) The commissioner of the Pollution Control Agency shall develop best management practices for state agencies and local units of government regulated under a national pollutant discharge elimination system or state disposal system permit for municipal separate storm sewer systems treating or cleaning up contaminated sediments in storm water ponds and other waters defined under paragraph (a) and make the best management practices available on the agency's Web site. As part of the development of the best management practices, the commissioner shall:

(1) sample a set of storm water pond sediments in residential, commercial, and industrial areas for polycyclic aromatic hydrocarbons and other contaminants of potential concern;

(2) investigate the feasibility of screening methods to provide more cost-effective analytical results and to identify which kinds of ponds are likely to have the highest concentrations of polycyclic aromatic hydrocarbons; and

(3) develop guidance on testing, treatment, removal, and disposal of polycyclic aromatic hydrocarbon contaminated sediments.

(d) The commissioner of the Pollution Control Agency shall incorporate the requirements for inventory and best management practices specified in paragraphs (b) and (c) into the next permitting cycle for the national pollutant discharge elimination system or state disposal system permit for municipal separate storm sewer systems.

Appendix I: MPCA's Notification on Coal Tar-based Sealcoat

DEPARTMENT: POLLUTION CONTROL AGENCY

SF-00006-05 (4/86)

STATE OF MINNESOTA

Office Memorandum

DATE: January 15, 2010

TO: All State of Minnesota
Agency Commissioners

FROM: Don Berger
State Program Administrator Principal
Stormwater Section
Municipal Division

PHONE: 651-757-2223

SUBJECT: Coal Tar Based Seal Coat for Driveways and Parking Lots

This memo provides you with information about:

- A new law restricting the use of coal tar based sealers on pavements such as driveways and parking lots.
- Background information about coal tar sealers and why they are being restricted.
- The potential for high cost to manage coal tar related pollutants which have accumulated in stormwater pond sediments.
- Work being done at the Minnesota Pollution Control Agency to estimate the size of the problem in Minnesota and identify potential solutions, and
- Whom to contact if you have questions.

Please distribute this information to anyone within your organization who may need to know about this restriction. This may include purchasing agents, contracting specialists, real estate managers, or others who may be affected by this new law.

In May of 2009 the Minnesota Legislature took action to restrict state agencies from purchasing coal tar sealers (see 2009 Session Laws, Chapter 172, and HF1231, sections 4, 26, and 28). **The law restricts *Minnesota* state agencies from purchasing undiluted coal tar sealers effective July 1, 2010**. Undiluted coal tar sealers are defined as any sealant containing coal tar that has not been mixed with asphalt and is intended for use on asphalt surfaces, including driveways and parking lots. Asphalt-based alternatives are available that have far lower levels of toxic chemicals, and are not affected by this restriction.

Notices are being distributed to state agency personnel who purchase, contract for services, or manage real estate to make them aware of the restriction. Minnesota Department of Transportation (Mn/DOT) specifications are already consistent with this requirement and no change in practice or policy is anticipated for Mn/DOT specifications.

Coal tar is a byproduct of coal processing which contains high levels of toxic chemicals called polycyclic aromatic hydrocarbons (PAHs). Some PAHs are classed as probable or possible carcinogens to humans. Coal tar is used in pavement sealers commonly called seal coat. Studies show that PAHs can be released into nearby surface waters and accumulate in sediments at potentially harmful levels when seal coat flakes off parking lots and driveways and is washed into stormwater ponds. This is a concern for anyone responsible for managing stormwater ponds and disposing of sediments dredged from them. A study has also linked coal tar sealers to higher levels of PAHs in dust found indoors near seal coated parking lots.

In 2007 the city of White Bear Lake was confronted with costs of at least $250,000 to manage contaminated sediment for just two ponds. The concentration of PAHs in the sediments and these costs to manage them is not unique to this community. PAH contamination is occurring in stormwater ponds and other waters across the state; however the problem is most common in densely urbanized areas such as the seven-county metropolitan area.

The MPCA is taking action to:

1. Notify state agencies about the coal tar restriction. This work is being done in collaboration with the Minnesota Department of Administration.

2. Get the word out to Minnesota municipalities, stakeholders, and citizens about the potential for PAH contamination in stormwater ponds.

3. Develop guidance and best management practices for treating and cleaning up contaminated sediments.

4. Create a model ordinance for restricting the use of coal tar sealers. The model ordinance is being developed in collaboration with the League of Minnesota Cities and will be made available to Minnesota municipalities in early 2010. Currently Dane County, Wisconsin, Washington D.C., and Austin, Texas have developed ordinances and enacted laws to restrict the use of coal tar sealers.

5. Fund research at the University of Minnesota to determine if biodegradation through composting of sediments could be a viable management option, and

6. Provide grants to local units of government for up to 50 percent of the costs to treat or clean up contaminated stormwater pond sediments or other contaminated waters as defined in statute.

For more information about stormwater, PAH contamination of stormwater ponds, or the legislation to restrict the use of coal tar sealers; visit www.pca.state.mn.us/water/stormwater/stormwater-ms4.html.

If you have questions about this notice or would like additional information, please contact:

Don Berger
State Program Administrator
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194
651-757-2223 or 800-657-3864
donald.berger@state.mn.us

DB:ah

cc: All State of Minnesota Agency Legislative Liaisons

Appendix J: MPCA's Stormwater Pond Inventory

Stormwater Pond Inventory
Municipal Separate Storm Sewer Systems (MS4s)

This inventory is required by Chapter 172, Sec. 28 of the 2009 Session Laws and is required to be incorporated into the 2011 revision and reissuance of the NPDES MS4 General Permit. The purpose of this inventory is to identify stormwater ponds, wetlands and other water bodies impacted by the collection, treatment and conveyance of stormwater. Water bodies may have received PAH as well as other types of contamination as a result of discharges via the stormwater conveyance system. Information previously gathered for purposes of mapping the stormwater management system, planning, inspections and maintenance activity should be used to help complete the inventory.

This is Stage 1 of a multi-stage inventory process. The Stage 1 inventory requirement s include:

- ID numbers of waters with stormwater discharges via a stormwater conveyance system; including lakes, ponds (natural & constructed), wetlands (natural & constructed), rivers, streams, creeks, ditches (not owned & operated by the MS4 or LGU), and ravines
- Locations of each of these waters
- Surface area of each of these waters
- Number of conveyance system discharge points to each of these waters

Schedule for meeting the Inventory Requirements

The Stage 1 inventory information will be due to MPCA with the permit application for the revised MS4 permit expected after June 1, 2011. This provides approximately 18 months to gather any new data required here that has not already been acquired through other stormwater management activities. The table below provides the inventory requirements and guidance on the type of data required to complete the inventory.

For updates on the status of the MPCA's tasks mentioned above, refer to the MPCA's Web page on "Restriction on Coal Tar-based Sealants" at: http://www.pca.state.mn.us/water/stormwater/stormwater-coaltar.html.

MS4 Stormwater Pond Inventory Data Requirements
January 15, 2010

<table>
<tr><th>Field Title</th><th>Field Guidance</th><th>Entry Options</th><th>Entry Option Guidance</th></tr>
<tr><td colspan="4">General Guidance: Include all water bodies within the jurisdiction of your MS4 that receive stormwater runoff via one or more components of your MS4 conveyance system. Such components may be pipes, ditches (owned & operated as part of your MS4), swales, gutters, streets, curbs, curb cuts, man-made channels, or other components.
This does <u>not</u> include:
• water bodies that receive only direct stormwater drainage through overland flow and/or conveyance components that are not part of your system
• structural pollution control devices such as sump manholes, grit chambers, separators, infiltration trenches and other small settling or filtering devices.
The information in this guidance may be modified at future times on the MPCA Web site for clarification.</td></tr>
<tr><td>Water Body ID#</td><td colspan="3">Two data fields will be provided. 1) Please use the State level numbering system for the State field when it exists; examples include public water #'s, DNR lake #'s, wetland survey #'s, and AUID #'s (for stream, river, or ditch segments). 2) Permittee ID# field- A permittee may use their own ID# numbering system; if you do not have a numbering system, you must create one. For water bodies that do not have a State level ID#, you may use your existing numbering system.</td></tr>
<tr><td rowspan="4">Water Body Type</td><td rowspan="4">Select one of the options that is appropriate for the water body</td><td>Constructed pond</td><td></td></tr>
<tr><td>Constructed wetland</td><td></td></tr>
<tr><td>Linear waters</td><td>Rivers, streams, creeks, ditches, or ravines</td></tr>
<tr><td>All other waters</td><td>lakes, ponds, or wetlands (i.e. not constructed)</td></tr>
</table>

Location	For most linear waters, enter the appropriate AUID# for the segment(s). For other waters (and ravines), enter a point in the approximate center.	Lat/long data	
		Coordinate system	Please use a widely-recognized coordinate system, such as a county coordinate system or UTM.
Year Put in Service	Use best available data.	Year constructed	
		Year connected	Use the year the water body was connected to your stormwater system. Use the outlet connection as your first choice. Use the connection of an inlet from your conveyance system as the second choice.
		Unknown	Where information cannot be obtained with reasonable effort, enter "Unknown"
Ownership	Enter the type of entity	City	
		County	
		Township	
		Watershed District	
		Private	
		Nontraditional MS4	MnDOT, public colleges, prisons, etc.
		State (all other public waters)	
		Unknown	Where information cannot be obtained with reasonable effort, enter "Unknown"

Maintenance Authority	Enter the type of entity responsible for operation and maintenance of the water body	City	
		County	
		Township	
		Watershed District	
		Private	
		Nontraditional MS4	MnDOT, public colleges, prisons, etc.
		State (all other public waters)	
		Unknown	Where information cannot be obtained with reasonable effort, enter "Unknown"
Size	Enter the approximate surface area (in acres) at normal water level as established by the outlet	Units = Acres	
Water Body Function	Under each option, enter "1" if primary function, enter "2" if secondary function	Water quality	
		Rate control	
		Flood control	
		Infiltration/Volume control	
		No control function	
		Unknown	Where information cannot be obtained with reasonable effort, enter "Unknown"

Number of inlets or conveyance system component discharge points to the water body	Such components may be pipes, ditches (owned & operated a part of your MS4), swales, gutters, streets, curbs, curb cuts, man-made channels, etc.). For example, this may be the number of pipe outlets to a pond.	Enter the number	
Number of outlets from the water body	Include constructed and non-constructed outlets. Do **not** include emergency overflow outlets.	Enter the number	

Appendix K: MPCA's Suggested City Ordinance Regulating the Use of Coal Tar-based Sealer Products

A CITY ORDINANCE REGULATING THE USE OF COAL TAR-BASED SEALER PRODUCTS

INTRODUCTION AND INSTRUCTIONS:

This ordinance contains a number of provisions a city may adopt. A city wishing to adopt this ordinance should review it with the city attorney to determine which provisions are suited to the city's circumstances. A city can modify this ordinance by eliminating provisions that concern activities it does not seek to regulate. The city attorney should review any modifications to ensure they conform to state law.

This model ordinance is drafted in the form prescribed by Minn. Stat. § 412.191, subd. 4, for statutory cities. Home rule charters often contain provisions concerning how the city may enact ordinances. Home rule charter cities should consult their charter and city attorney to ensure that the city complies with all charter requirements. If your city has codified its ordinances, a copy of any ordinance regulating the use of coal tar-based sealers must be furnished to the county law library or its designated depository pursuant to Minn. Stat. § 415.021.

This ordinance may affect current blacktop sealer practices within the city's jurisdiction. Therefore, prior to ordinance adoption, the city may want to provide commercial sealer companies, city residents, and other interested persons an opportunity to provide input.

ORDINANCE NO. _____________

AN ORDINANCE REGULATING THE USE OF COAL TAR-BASED SEALER PRODUCTS WITHIN THE CITY OF____________, MINNESOTA

SECTION 1. PURPOSE.

The City of __________ understands that lakes, rivers, streams and other bodies of water are natural assets which enhance the environmental, recreational, cultural and economic resources and contribute to the general health and welfare of the community.

The use of sealers on asphalt driveways is a common practice. However, scientific studies on the use of driveway sealers have demonstrated a relationship between stormwater runoff and certain health and environmental concerns.

The purpose of this ordinance is to regulate the use of sealer products within the City of _________, in order to protect, restore, and preserve the quality of its waters.

SECTION 2. DEFINITIONS.

Except as may otherwise be provided or clearly implied by context, all terms shall be given their commonly accepted definitions. For the purpose of this ordinance, the following definitions shall apply unless the context clear indicates or requires a different meaning:

ASPHALT-BASED SEALER. A petroleum-based sealer material that is commonly used on driveways, parking lots, and other surfaces and which does not contain coal tar.

COAL TAR. A byproduct of the process used to refine coal.

UNDILUTED COAL TAR-BASED SEALER. A sealer material containing coal tar that has not been mixed with asphalt and which is commonly used on driveways, parking lots and other surfaces.

CITY. The City of _________________.

MPCA. The Minnesota Pollution Control Agency.

PAHs. Polycyclic Aromatic Hydrocarbons. A group of organic chemicals formed during the incomplete burning of coal, oil, gas, or other organic substances. Present in coal tar and believed harmful to humans, fish, and other aquatic life.

SECTION 3. PROHIBITIONS.

A. No person shall apply any undiluted coal tar-based sealer to any driveway, parking lot, or other surface within the City of _______________.

B. No person shall contract with any commercial sealer product applicator, residential or commercial developer, or any other person for the application of any undiluted coal tar-based sealer to any driveway, parking lot, or other surface within the City.

C. No commercial sealer product applicator, residential or commercial developer, or other similar individual or organization shall direct any employee, independent contractor, volunteer, or other person to apply any undiluted coal tar-based sealer to any driveway, parking lot, or other surface within the City.

SECTION 4. EXEMPTION.

Upon the express written approval from both the City and the MPCA, a person conducting bona fide research on the effects of undiluted coal tar-based sealer products or PAHs on the environment shall be exempt from the prohibitions provided in Section 3.

SECTION 5. ASPHALT-BASED SEALCOAT PRODUCTS.

The provisions of this ordinance shall only apply to use of undiluted coal tar-based sealer in the City and shall not affect the use of asphalt-based sealer products within the City.

SECTION 6. PENALTY.

Any person convicted of violating any provision of this ordinance is guilty of a misdemeanor and shall be punished by a fine not to exceed one thousand dollars ($1,000.00) or imprisonment for not more than ninety (90) days, or both, plus the costs of prosecution in either case.

SECTION 7. SEVERABILITY.

If any provision of this ordinance is found to be invalid for any reason by a court of competent jurisdiction, the validity of the remaining provisions shall not be affected.

SECTION 8. EFFECTIVE DATE.

This ordinance becomes effective on the date of its publication, or upon the publication of a summary of the ordinance as provided by Minn. Stat. § 412.191, subd. 4, as it may be amended from time to time, which meets the requirements of Minn. Stat. § 331A.01, subd. 10, as it may be amended from time to time.

Passed by the Council this ______ day of ______________________, 20_____.

____

Mayor

Attested:

____

Clerk

Appendix L: News Story on Coal Tar Sealcoat Products

From: KARE 11 News at: http://www.kare11.com/news/news_article.aspx?storyid=530149&catid=2

Sealcoating parking lots, driveways could be harming Minnesota's urban lakes

Updated: 11/22/2008 1:18:41 PM

Any vigilant homeowner will tell you it's part of their routine.

But sealcoating that driveway or parking lot against 4-season frost/thaw damage may also be harming nearby lakes, rivers, and watersheds.

"Urban settings, there are going to be alot of intense land uses," explained Bruce Wilson of the Minnesota Pollution Control Agency. "And there's going to be a lot of chemicals that originate, and there's going to be run off from those, that finds it's way into our waterways."

A new study by the U-S Geological Survey suggests that Coal-Tar based sealcoats may be responsible for polluting lakes from coast to coast, including two right here in Minnesota.

Lake Harriet in Minneapolis, and Palmer Lake in Brooklyn Center were two of ten lakes sampled in the study. Researchers found levels of P-A-H in the two lakes was above the probable effect concentration where you see impact on animal and plant life.

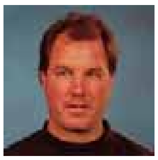
"P-A-H's are Polycyclic Aromatic Hydrocarbons," said Wilson. "Of those, we know 16 are pretty nasty, from a standpoint of either toxicity to aquatic organisms, or they're known or suspected human carcinogens."

Researchers say when Coal-Tar sealcoats wear off, they create a dust that blows or is washed into the watershed by rain. That dust contains high levels of P-A-H.

"We're trying to put these pieces together," assured Wilson, "trying to figure out how extensive is the problem, what are the sources, and then what can we do on a management standpoint."

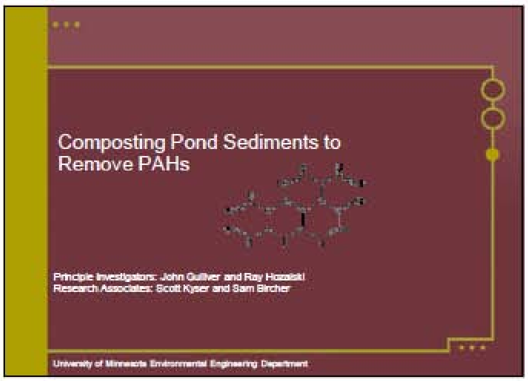
One thing Wilson urges is that consumers and small contractors check the labels of the sealcoat they buy, and make sure it is 'not' Coal-Tar based. He says that the compound may eventually end up being banned in Minnesota.

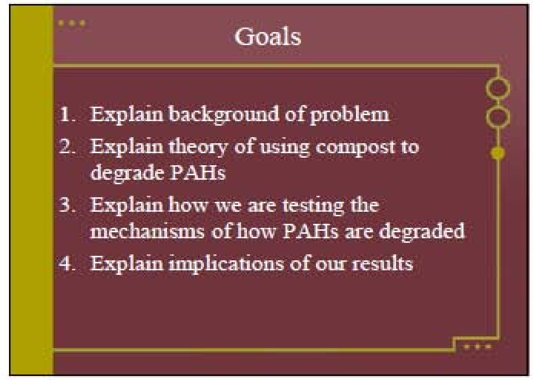
Many government agencies like the city of Minneapolis have to adhere to the same bidding standards that MnDOT does, which means only Asphalt-based sealcoating can be used. Minneapolis Public Works Director Mike Kennedy says his city hasn't used Coal-Tar based sealcoat for years.



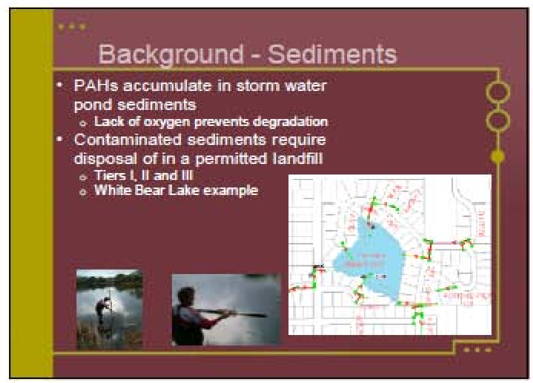
By Dana Thiede, KARE 11 News

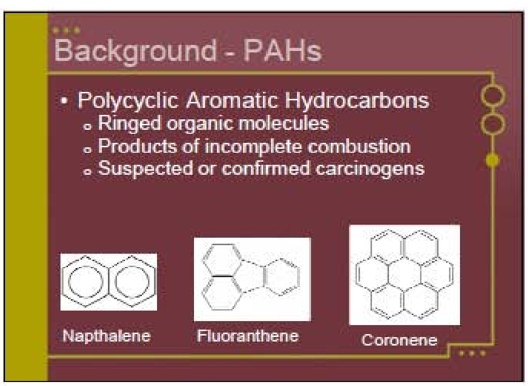
Appendix M: Presentation by University of Minnesota Researchers on "Composting Pond Sediments to Remove PAHs"

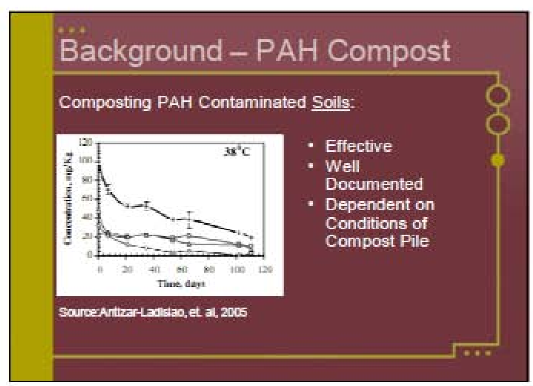

Composting Pond Sediments to
Remove PAHs
Principle Investigators: John Gulliver and Ray Hozalski
Research Associates: Scott Kyser and Sam Bircher
University of Minnesota Environmental Engineering Department


Goals
1. Explain background of problem
2. Explain theory of using compost to degrade PAHs
3. Explain how we are testing the mechanisms of how PAHs are degraded
4. Explain implications of our results


Background – Stormwater Ponds
• MN has thousands of ponds
• Design life 15-20 years
• Dredging rejuvenates function
• Dredged sediments typically allowed to dry and land spread
• Costly


Background - Sediments
• PAHs accumulate in storm water pond sediments
o Lack of oxygen prevents degradation
• Contaminated sediments require disposal of in a permitted landfill
o Tiers I, II and III
o White Bear Lake example


Background - PAHs
• Polycyclic Aromatic Hydrocarbons
o Ringed organic molecules
o Products of incomplete combustion
o Suspected or confirmed carcinogens
Napthalene
Fluoranthene
Coronene


Background – PAH Compost
Composting PAH Contaminated Soils:
38°C
Concentration, mg/kg
Time, days
• Effective
• Well Documented
• Dependent on Conditions of Compost Pile
Source:Antizar-Ladislao, et. al, 2005

Background Theory

PAH + Microbes + Nutrients + O_2 + H20 = C02 + H20 + Heat

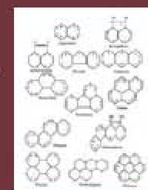
Goal: Optimize Compost
-Oxygen
-Nutrients
-Water
-Microbial Activity

Research Question

Can PAH contaminated sediment be remediated using compost?

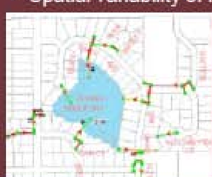
Method Overview

A.Two Benchtop Experiments
1. Variable temperature
2. Temperature Controlled
B. Field Trial
1.large scale trial of PAH composting



Sediment Characterization

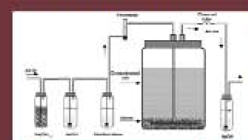
- White Bear Lake sediments
  - Mostly high molecular weight PAHs
  - 5-30 mg/kg range
  - Above tier III dredged material limits
- Spatial variability of PAH concentrations

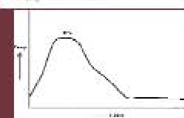


Benchtop Experiment Variable Temperature

Goal: Determine fate of PAHs in compost pile

- Allow for natural temperature progression
- Test
  - PAH degrading enzymes
  - CO_2 Respiration
  - Volatilized PAHs
  - PAH degradation
- 5 Liters of compost per reactor



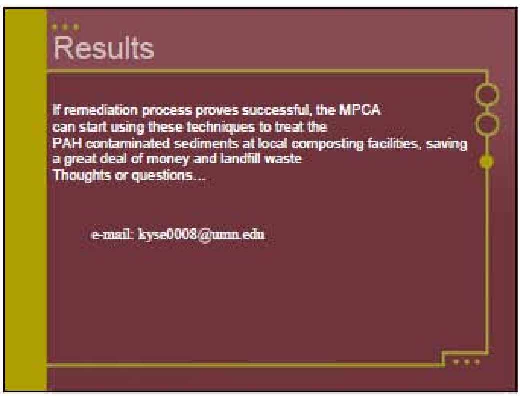


Benchtop Experiment Temperature Controlled

Goal: Determine Optimal Compost to Sediment Ratio

- Constant Temperature
- 0.5L reactors
- Vary ratio of Compost to Sediment
  - 8:1, 4:1 , 2:1
- Run for 90 days


Field Trial
Goal: Determine Ability of Compost to Break Down PAHs in a Field Setting
• 2-5 cubic meter piles
• Temperatures below 50°C
• Set to begin in May 2009
Site voluntarily provided by Resource Recovery Technologies


Results
If remediation process proves successful, the MPCA can start using these techniques to treat the PAH contaminated sediments at local composting facilities, saving a great deal of money and landfill waste
Thoughts or questions…
e-mail: kyse0008@umn.edu


Many thanks to…
•Bruce Wilson
•MPCA
•Tom Halbach
•Bruce Cook
•Raymond Hozalski
•John Gulliver
•Sam Bircher
•Matt Simcik
•Minnesota Mulch and Soil
•Resource Recovery Technologies
e-mail: kyse0008@umn.edu

Appendix N: MPCA Fact Sheet on Coal Tar-based Sealcoat: Environmental Concerns

This fact sheet is available on the MPCA's Web site at: http://www.pca.state.mn.us/publications/wq-strm4-12.pdf.

Minnesota Pollution Control Agency

Coal Tar-based Sealcoat

Environmental concerns

wq-strm4-12 • September 2009

If you decide to sealcoat your asphalt driveway this year, there are a few things you should know. Sealcoating makes old asphalt look new and protects its surface, but there are serious environmental concerns with its use.

Sealcoat comes in two basic varieties: coal tar-based and asphalt-based. The coal tar variety is more resilient, but it contains much higher levels of a class of chemicals called PAHs (polycyclic aromatic hydrocarbons) that harm fish, and with prolonged exposure, pose a risk of cancer in humans (see Figure 1).

Environmental problems

Coal tar is a waste material generated in the conversion of coal to coke. Manufacturers choose coal tar for sealcoat because of its resistance to petroleum products like gasoline and oil, which drip from cars and deteriorate asphalt surfaces. In time, sunlight and vehicle traffic wears down sealcoat and sealcoat flakes are washed away by rain or carried away by wind, contaminating stormwater ponds, streams and lakes with PAHs.

PAHs cause tumors in some fish, disrupts the reproduction of aquatic organisms, and causes some water-bottom species to avoid sediment altogether. Health risks to humans related to PAHs are based on the length of exposure to vapors or sediments contaminated with PAHs.

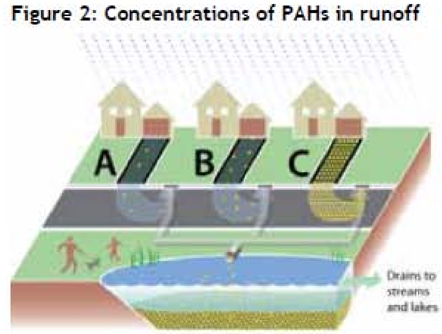
PAH Concentrations

Coal tar contains as much as 30 percent PAHs by weight. A study in Austin, Texas, compared the level of PAHs in water coming off parking lots without sealcoat to water coming off parking lots coated with asphalt- and coal-tar sealcoat (Figure 2).

Figure 1: Relative amounts of PAHs in sealcoat products

An Austin, Texas, study determined that sealcoat products based on coal tar contained up to 1,000 times more PAHs than asphalt-based products. Consider asphalt-based sealcoat if you choose to coat your driveway.

Figure 2: Concentrations of PAHs in runoff



Asphalt-based sealcoat runoff (B) can contain 10 times more PAHs than an uncoated driveway (A) and runoff from a coal-tar sealcoated driveway (C) may have concentrations of PAH 65 times higher than an uncoated driveway.

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The study revealed that the asphalt-based sealcoat runoff contained 10 times more PAH than the uncoated parking lot and the coal-tar sealcoat runoff had concentrations of PAH that were 65 times higher than the uncoated lot.

Maintenance expenses

Besides the health effects and the danger to the environment, PAHs are making routine maintenance of stormwater ponds by cities and townships many, many times more expensive because sediment with high-enough concentrations of PAHs must be disposed of differently.

In Minnesota, when some cities removed sediment from their stormwater ponds as part of regular maintenance, they found elevated levels of PAHs. This discovery required them to find special disposal areas, costing them many thousands of dollars more.

Current regulation

Because of the environmental problems associated with PAHs, the City of Austin, Texas, Dane County, Wisconsin, and Washington D.C. have banned use of coal tar-based sealcoat in their jurisdictions (asphalt-based sealcoat may still be used).

Recent legislation passed in Minnesota bans the purchase of coal-tar sealcoat products by state agencies by July 1, 2010. Recently, two national home-improvement retailers, Lowe's and Home Depot, took coal tar-based sealcoat off their shelves. Check with your local unit of government to see if there are any restrictions.

Make the right choice

The best choice may be to not sealcoat your driveway at all. But if you do choose to sealcoat, study labels carefully to be sure to find an asphalt-based product. Lower concentrations of PAHs in waterways will prevent costly maintenance for your city and keep waterways safe for fish and other aquatic organisms.

If you have leftover material after sealing your driveway, you can re-use or recycle it at your community's household hazardous waste facility. To find your local facility,
visit: www.pca.state.mn.us/waste/hhw

References

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